THE FEBRUARY SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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RECENT BOOKS OF SCIENTIFIC INTEREST

with comments by the publisher

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A narrative of western culture and education from their beginning to the end of the sixteenth century. Emphasis is placed upon those aspects essential for understanding both western tradition and present educational problems.

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Animal Life of the Carlsbad Cavern. VERNON BAILEY. 76 pp. 66 illustrations. Williams & Wilkins Company, Baltimore.

The story of animal life in one of the natural wonders of the West. In text and pictures the whole story is presented in such a way as to interest the specialist as well as the amateur.

Cultural Evolution. CHARLES A. ELLWOOD. $2.50. Century Company, New York.

The work goes back to the beginning of civilization and carefully traces the various stages in social development, noting the nature and method of cultural evolution and studying the various theories bearing upon the causes of cultural development.

The Foundations of Education. J. J. FINDLAY. 376 pp. $3.00. Henry Holt & Company, New York.

A systematic exposition of the principles and practice of teaching, treating especially the content of learning, the elements which we call social experience and the nature of the child.

Sir Isaac Newton. S. BRODETZKY. 155 pp. Methuen & Company, London.

An account of Newton's life and personality, combined with a statement of his scientific achievements. Written in a manner that will be understood by the general reader who has a moderate grounding in the elements of science.

Living Machinery. A. V. HILL. 300 pp. $3.00. Harcourt, Brace, New York.

Eight lectures delivered at the Lowell Institute, discussing the mechanical behavior of the nerve and muscle systems of the human body. The book is not technical and is well illustrated with plates and sketches.

THE SCIENTIFIC MONTHLY

FEBRUARY, 1928

TWO EXPEDITIONS AFTER LIVING PLANTS

THE ALLISON V. ARMOUR EXPEDITIONS OF 1925–27, INCLUDING TWO VOYAGES IN THE ESPECIALLY EQUIPPED YACHT UTOWANA[1]

By DAVID FAIRCHILD

OFFICE OF FOREIGN PLANT INTRODUCTION, U. S. DEPARTMENT OF AGRICULTURE

MOST botanical expeditions in the past have been for the purpose of discovering new species of plants which would broaden the horizon of botanical knowledge. The Allison V. Armour expeditions, of which this is the first description to be published, were for the purpose of collecting the living seeds and plants of any species, whether wild or cultivated, described or new, which appeared likely to have any definite use when cultivated in America. They might properly be considered as expeditions in the interest of the work of plant introduction of the United States Department of Agriculture and resembled in kind previous expeditions which the late Barbour Lathrop, of Chicago, financed during the years between 1898 and 1903, on which I acted as agricultural explorer.

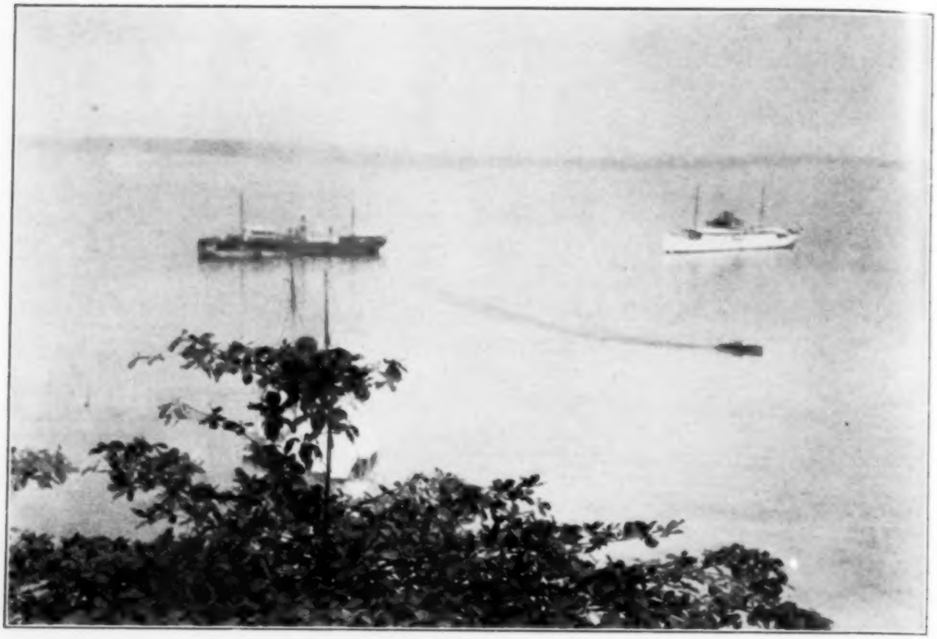
The period covered by the Allison V. Armour Expeditions was from September, 1924, to April, 1927, and the regions visited included the following countries: England, France, Belgium, Holland, Switzerland, Sweden, Germany, Italy, Spain, Portugal, Algeria, Morocco, Ceylon, Sumatra, Java, the Straits Settlements, the Canary Islands, the Balearic Islands, Gambia, Senegal, French Guinea, Sierra Leone, Liberia, the Gold Coast, the Cameroon, both French and British mandated territory.

Only a limited time was spent in any one country—the object being primarily to get in touch with the scientific plant men of the various countries; to make arrangements for a plant exchange with them, and at the same time secure what plant material was immediately available for introduction into America.

The following scientific men were at one time or another associated with me as the guests of Mr. Armour, either on his yacht *Utowana*, or on various collecting trips by automobile and truck into the interiors of the less well-known regions visited.

Dr. William Morton Wheeler, of Bussey Institution, Harvard University, whose work was exclusively with insects; my colleague, Mr. P. H. Dorsett, of the Office of Foreign Plant Introduction, of the Bureau of Plant Industry, Department of Agriculture; Dr. H. H. McKinney, plant pathologist of the office of Cereal Investigation, Bureau of Plant Industry, U. S. Department of Agriculture, whose work was mainly with the

[1] Unless indicated to the contrary the photographs have been taken by David Fairchild.



THE YACHT *Utowana* AS SHE LAY IN THE HARBOR OF STA IZABEL FERNANDO PO, WITH HER STARBOARD LAUNCH BRINGING PASSENGERS ASHORE. THE ARRIVAL OF THE BEAUTIFUL WHITE BOAT IN THESE HARBORS OF THE WEST COAST OF AFRICA WAS GENERALLY SOMETHING OF AN EVENT. SHE IS HERE SHOWN IN COMPARISON WITH A TRAMP STEAMER SUCH AS COMMONLY PLIES UP AND DOWN THE COAST. NO YACHT HAS EVER BEEN MORE COMPLETELY FITTED UP FOR COLLECTING WORK THAN WAS THE *Utowana*.

virus diseases of plants; Dr. J. M. Dalziel, of the Kew Herbarium, coauthor with Dr. Hutchison, of the New Flora of West Africa, who in addition to his botanical work acted as medical officer of the yacht. Acting as photographers and general assistants, J. H. Dorsett, Fred W. Schultz and my son Graham Bell Fairchild, were attached to the various expeditions. Mrs. Fairchild accompanied the expedition to Morocco and the Orient and contributed much to its success there.

The technique of this type of exploration work is perhaps better understood by horticulturists than by botanists, for it involved the transport, for purposes of propagation, of living seeds and cuttings from one country to another. The classic examples of this kind of exploration work are furnished by such voyages as that of Lieutenant Bligh, on H. M. Ship *Bounty* to Tahiti, to secure the seedless breadfruit tree; and the voyage of Wickham in 1876 to Brazil after the Para Rubber Tree (*Hevea Braziliensis*), which resulted in the former case in the cultivation of the breadfruit tree in the West Indies, while Wickham's made possible the gigantic plantation rubber industry in the Orient.

The yacht *Utowana*, which Mr. Armour had equipped especially for collecting purposes, embodies some novel equipment, such as a well-lighted laboratory for microscopical work; a delightfully arranged library with desks and bookshelves; a dark room; a special device for drying seeds and specimens; a deck to hold Wardian cases on and

ample storage space for supplies of all sorts.

Two launches furnished the means for getting on shore and a crew of 30 men ran the yacht. The *Utowana* is a boat of 1,315 tons weight; 230 feet in length; 33 ft. 10 inch beam; 11 to 12 ft. draft, provided with two Atlas Diesel 500 H. P. engines, capable of pushing it 10½ knots an hour through the water and it has complete electrical equipment; a cruising radius of 12,000 sea miles; water tanks holding 200 tons of water, and space in its cold storage rooms for provisions to supply an excellent and varied menu for a six months cruise.

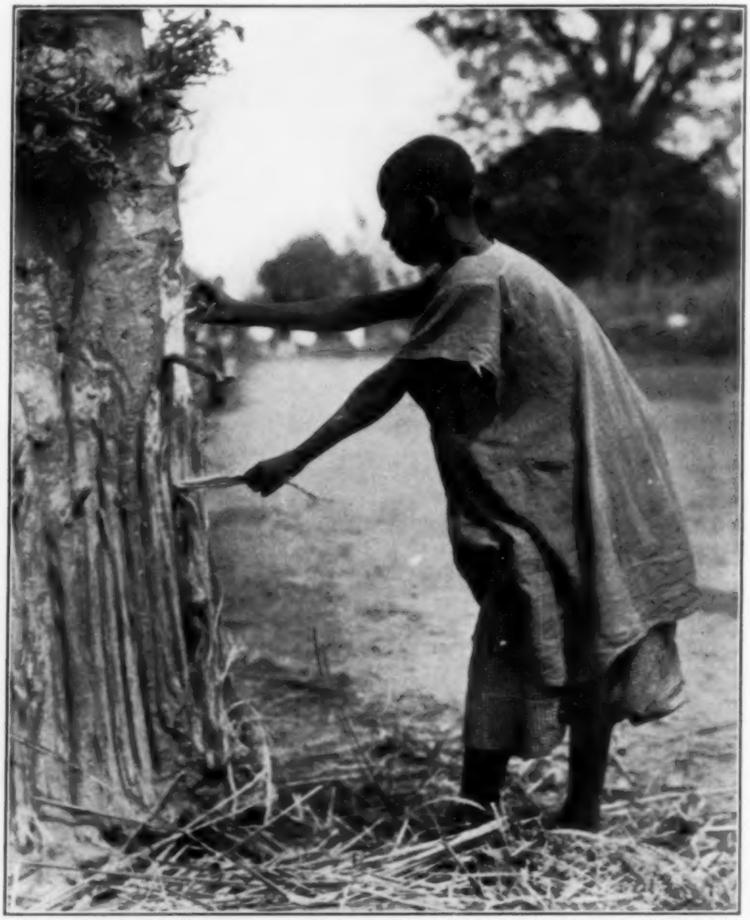
The original intention was to visit the Moluccas and the plans were made to do this in 1925, but quite unexpected delays in the completion of the remodeling of the yacht were met with in the winter of 1924–25, and instead of her being ready to sail in December, 1924, she was not in the water until May of 1925.

During these months of delay I was able to look up many matters of importance in various of the herbaria of Great Britain and Europe and carry out a three months' collecting trip in our own car in Algiers and Morocco accompanied by Mrs. Fairchild, Dr. W. M. Wheeler and my son Graham.

The yacht arrived at Casa Blanca in May with Mr. Armour and Mr. and Mrs. Jordan Mott on board and we made a trial cruise through the Canary Islands and Balearic Islands preparatory to the Molucca trip which was scheduled to start October, 1925.

On the eve of departure from Naples, however, the *Utowana* developed serious engine trouble which eventually made Mr. Armour abandon taking her to the Dutch East Indies and the expedition went on by regular steamer. Mrs. Fairchild, Graham and I were joined in Ceylon by Mr. Dorsett and his son who had been exploring for plants in Man-

THERE IS AN INDESCRIBABLE CHARM ABOUT THE GAMBIA RIVER REGION AS WE SAW IT IN THE EARLY MORNINGS FROM THE DECK OF THE YACHT. IT WAS THE WINTER SEASON, THE AIR WAS FRESH AND WE HEARD AN EXTRAORDINARY NUMBER OF BIRDS. THE TREES WHICH DOT THE PLAIN ARE THE SILK COTTON, MANGO, RHUN PALM (*Borassus ethiopum*) AND, IN THE DISTANCE ON THE RIGHT, THE DOUM, OR GINGERBREAD PALM (*Hyphaene thebiaca*) WHICH HAS THE CHARACTER, UNIQUE AMONG PALMS, OF POSSESSING NORMALLY A BRANCHING TRUNK.



STRIPPING BARK FOR ROPE-MAKING FROM A BAOBAB TREE IN THE GAMBIA. THE GIANT ANTEDILUVIAN TREES OF THIS *Adansonia digitata*, WHICH ARE SCATTERED OVER THE PLAINS ON EITHER SIDE OF THE GAMBIA RIVER, ARE CURIOUSLY SCARRED FROM HAVING HAD THE BARK REMOVED IN THE WAY SHOWN. FOR CENTURIES THE INHABITANTS HAVE MADE THEIR ROPES OF THIS FIBROUS BARK. WHEN A NATIVE WANTS A ROPE HE GOES TO A TREE INSTEAD OF TO A STORE.

churia for the Department of Agriculture, and who had been invited by Mr. Armour to form a part of the expedition to the Moluccas.

After two months in Ceylon we left on February 13 for Sumatra where we stayed until March 31 doing more or less intensive collecting work. We purchased a car with which we were able to traverse the excellent roadways of North Sumatra and pentrate into the region about Lake Tawar—which is one of the most remarkable and least visited regions of all Sumatra—with a flora that is very imperfectly known and jungles which rival in beauty and mystery any I have ever seen anywhere.

Through the courtesy of the Governor of Sumatra who put us in touch with Mr. Brandts Buys, the head forester of

the island, we were able to organize a collecting journey of two weeks duration covering a distance of jungle trail over two hundred miles long directly through the virgin forests of Atcheen. This wonderful two weeks trip was made on foot by Mr. Dorsett and his son, and my son Graham without encountering any difficulty with the Atchenese even though the day before they started a massacre of Dutch troops had taken place on the West Coast some fifty miles only from the line of march. This was the first of one of those short series of outbreaks which have characterized the behavior of the Atchenese toward the Dutch for the past half century, and has not in my opinion the particular significance from the Moscow standpoint, which has been attributed to it by sensational writers in American journals.

The expedition did some of its most interesting collecting work in one of the most remarkable botanic gardens in the world. It would be hard to find, I believe, any region in the tropics which is to-day more interesting as a collecting field than that of the Sumatran highlands, a plateau comprising more than a million acres of virgin grass land penetrated by deep jungle-covered valleys and all lying from 3 to 4,500 feet above sea-level where the climate is drier by 20 per cent. than that common to mountain peaks in the tropics (20 per cent. drier than Newara Eliya, Ceylon, for example) and where until fourteen years ago cannibalism existed. From Sumatra we left, March 31, for Java, and, after spending several weeks in the region about Buitenzorg, motored across the island, collecting mainly cultivated plants in the densely settled portions of that remarkable island. We had a glimpse of that most extraordinary plant, *Rafflesia patma*, which has flowers sixteen inches across, and which occurs abundantly on the Convict Island of Noesa Kambangan; we visited the Djeng Plateau, the oldest center of prehistoric civilization in Java; the central Sultanates of Djokja and Solo and the hot dry region of East Java. In April the Dorsetts returned to their collecting work in Manchuria and in June the rest of us went back to Europe *via* Egypt.

In the meantime Mr. Armour had taken the *Utowana* to Stockholm to equip her with new engines and cabled us that he would be ready in December to undertake a trip down the West Coast of Africa. Accordingly in the fall a new staff of scientific men for the West African trip was gotten together in Washington, and early in December, Mr. and Mrs. Francis Whitehouse, sister and brother-in-law of Mr. Armour; my assistant, F. W. Schultz, and I sailed for Gibraltar. There we met Mr. Armour on the yacht *Utowana* with her new engines installed and with Dr. Dalziel and Dr. McKinney already on board.

Leaving Gibraltar on the eighteenth of December, we spent Christmas in Teneriffe and left for the Gambia River on the last day of the year 1926. The following itinerary of the yacht *Utowana* indicates the character of the cruise down the West Coast of Africa which, while it admitted of no prolonged stay in any one place, afforded a unique opportunity for comparisons to be made of the floras and climates and civilization, so called, of the European Colonies on this great West African Coast.

The winter season from November to April is the only one in which a small yacht could navigate the waters of this coast and land passengers with any degree of certainty, owing to the absence of harbors and the high surf, which has to be crossed in special surf boats, paddled by gangs of Kroo boys. The almost complete absence of hotels, furthermore, complicates any prolonged work on shore.

A BEAUTIFUL GIANT AROID OF THE CAMEROON (*Cyrtospermum senegalense*). DR. DALZIEL, OF THE EXPEDITION, IS STANDING IN A PATCH OF THIS AMAZING AROID WHICH COVERED A QUARTER OF AN ACRE. THE TWO-FOOT SPATHES ARE RAISED TEN FEET INTO THE AIR ON SQUARE ANGULAR SPINY STALKS. THERE ARE LARGER AROIDS THAN THIS BUT NONE WHICH GROWS IN MASSES OR MAKES A MORE STRIKING SHOW. FOUND BACK OF DUALA, CAMEROON.

Itinerary of Cruise

	Arrived		Left	
Bathurst, Gambia	Jan.	4	Jan.	12
Konakry, French Guinea	"	15	"	17
Freetown, Sierra Leone	"	17	"	26
Monrovia, Liberia	"	27	"	28
Sta Isabel, Fernando Po	Feb.	3	Feb.	4
Duala, Cameroon	"	4	"	8
Victoria, Nigeria	"	8	"	21
Accra, Gold Coast	"	24	"	26
Takaradi, Gold Coast	"	27	March	2
Konakry, French Guinea	March	7	"	12
Dakar, Senegal	"	14	"	17
Las Palmas	"	20	"	23
Gibraltar	"	27	April	1
Lisbon	April	6	"	10
Bordeaux	"	13	"	17

Transportation on the West Coast of Africa is improving rapidly with the building of networks of good roads and the importation of hundreds of small but high-powered automobiles. Soon it will be possible to reach almost any of the important regions by automobile, but at present any general view, such as we had, would be practically impossible without a special boat. The natives are so thoroughly infected with malarial parasites that prolonged stay in West Africa exposes any exploring party to the West African fever, but we were there during the best season of the year when there were almost no mosquitoes about and thanks to our isolation on the yacht only one of our party suffered from fever.

Ordinarily the results of botanical collecting trips can be measured by the numbers of specimens collected and the number of new species discovered among these specimens. These latter represent positive new scientific data. Such a yardstick as this, however, is in no way applicable to plant introduction work, for here we deal with a transferring of plants from one country to another, not with the discovery of new species of plants. Furthermore, numbers of plants collected do not tell the story, for those which arrive dead represent futile attempts. A more reasonable measure of the results would be through an account of the successful growth of the species of plants introduced. But here again enters another difficulty—the time element. Plants grow so slowly that years must pass before one can know whether seeds transplanted from one region will grow and produce in another. In 1876 Hevea seeds were sent from Brazil *via* Kew to Ceylon. A year after this introduction was made there were only tiny seedlings to show that the Brazilian immigrant would grow in its new environment. Twenty years later only a few men like Ridley, of Singapore, believed that this Brazilian rubber tree was to be a commercial success in the Orient, and although to-day billions of dollars are invested there in the rubber plantations which grew from the seeds of those trees—half a century of time has passed and the actors in the drama are most of them dead.

Perhaps it were better in writing of this kind of an expedition to look upon the introduction from a foreign country of a plant new to the country into which it is sent, as the procuring of the materials for an experiment. The experiment is successful only when that plant comes into some use or other somewhere in that country.

As a result then of our expeditions we have brought in as experimental material some 1,400 species of plants and made about 2,500 photographs of plant industries and nothing short of a two-volume book could adequately describe these results of two and a half years of plant collecting in Europe, Africa and Asia.

A brief summary is possible, however, and it will perhaps serve the purpose of placing the expedition in historical literature, so that those later who study the dried specimens which were collected or who grow the living plants can at least find out where the expedition went

—*Photo by F. W. Shultz*

VIEW IN THE BOTANIC GARDENS OF VICTORIA, CAMEROON. THIS IS THE MOST EXTENSIVE BOTANIC GARDEN ON THE WHOLE WEST COAST OF AFRICA. IT WAS BUILT UP BY PROFESSOR P. PREUSS AND UNTIL THE WAR WAS CAREFULLY MAINTAINED. EVEN NOW, AFTER YEARS OF NEGLECT, IT REMAINS ONE OF THE GREAT COLLECTIONS OF TROPICAL TREES AND PLANTS. A NEW DIRECTOR HAS JUST BEEN SENT OUT FROM KEW, AND IT IS HOPED THAT HE WILL BE ABLE TO BRING IT BACK TO THE CONDITION IN WHICH IT WAS UNDER GERMAN SUPERVISION.

and where it did its work in the various countries visited. The dried specimens collected and the photographs made will be found either in the herbarium of the Office of Foreign Plant Introduction in the Bureau of Plant Industry in Washington or in the Kew Herbarium.

Of the personal characteristics of the big-hearted man whose conception it was to equip a yacht which would be of real use in the search for useful plants, I find it very hard to write, because he belongs to that very rare class of human beings to whom the doing of things that are worth while, rather than the talking about what you have done, is a deep-seated instinct. To compliment him to his face embarrassed him, and I have the feeling that to do it in print will be quite as embarrassing, although as a matter of fact I know of no man in the whole world who could have distinguished himself more completely for downright unparalleled unselfishness in everything which he did to make the cruise of the *Utowana* a success. His passion for making conveniences which he thought the scientific staff needed went so far at times that it took him into the boiling hot hold of the yacht in the hottest part of the Tropics where he had fitted up his own particular shop and where he kept his own kit of tools. I doubt if there was ever a cruise where the guests were made more thoroughly comfortable or where the personal equation was more perfectly under control than it was on the cruise of the *Utowana* down the West Coast of Africa.

As for the so-called unscientific staff—composed alternately of the Motts and the Whitehouses—it did everything possible to further the work of the expedition.

Relatives of the Mangosteen

The work of the expedition started in the Herbaria of Kew, Paris, Leiden and Geneva (Conservatoire de Botanique) with an examination of the material belonging to the genus *Garcinia*, which revealed the existence of over a hundred species having more or less edible fruits and supplied the data requisite for a systematic search for the seeds of the promising relatives of the Mangosteen (*Garcinia mangostana*), *i.e.*, promising as new fruits or as a stock for this famous fruit tree of the Orient.

The data secured will enable visits to be made to the original localities where the various dried specimens were collected, but as these localities are scattered from South America to New Guinea, and include localities which are peculiarly isolated, and since these localities must be visited at the right season, and since the shipment of living Garcinia seeds is a precarious undertaking anyhow, the work of assembling even a majority of the one hundred and thirty promising Garcinia species in any single tropical Arboretum assumes the dimensions of a life-long problem. Seeds of ten species were, however, located in Ceylon, Sumatra, Java and West Africa and sent to America for experimental use. Contrary to a hope that some really rapidly growing species might be found, I was disappointed to discover that none of the ten studied grow much faster than the mangosteen itself. The great beauty of the Garcinia trees makes them valuable, however, as dooryard and park trees wherever they can be grown, and those introduced may beautify the parks and gardens of Panama, Porto Rico, Hawaii and Cuba, and furnish material for the plant breeders later on and be used as stocks upon which to grow the mangosteen.

Burr Clovers and Other Leguminose Plants

The success which has attended the introduction of the Mediterranean species of burr clovers (*Medicago* sp.) into California and some of the Southern

States made it seem worth while to collect in the Canary Islands, Morocco, Algeria, Southeastern Spain and the Balearic Islands all the species possible for the purpose of testing them further in our own South and West.

The various species of the genus play a remarkable rôle in the enrichment of the soil and the maintenance of the sheep and goat forage of the whole Mediterranean basin. The roadway ditches, the calcareous hillsides, the fruit orchards, the sandy soils of the cork oak forests, the rocky sides of the Barrancos and even the sandy areas that skirt the seashore are everywhere inhabited by one or more species of this remarkable genus. Their nutritious stems furnish an immense amount of forage during the spring or rainy season and their nodules add nitrogen to the soils, and when the dry season arrives the millions of seed pods which they produce furnish a highly concentrated food for the sheep and goats which everywhere in this region range the roadways and dry hillside pastures.

During our visits to Ceylon, Sumatra and Java rather large collections of leguminous plant species were put at our disposal by the experimenters of the various agricultural institutions with which the British and Dutch colonies are now so well supplied. Whereas these had been made for the purpose of studying the effects of ground covers in the rubber and tea plantations, to stop erosion and add nitrogen to the soil, there is little doubt but that among those which were presented to the expedition some will prove of distinct value in the southern states of America.

European Collections

The collection of recently introduced plants which are to be found in European botanic gardens and Arboreta furnished much interesting material for

DR. SAWYER AND DR. WOLCOTT, OF THE ROCKEFELLER INSTITUTE, TOURING THE GOLD COAST IN THEIR SEARCH FOR THE CAUSES AND REMEDIES OF WHAT IS CALLED YELLOW FEVER IN WEST AFRICA. DR. WOLCOTT HAS THE DISTINCTION OF BEING THE ONLY WHITE MAN WHO DARES TO WEAR A FELT HAT OUT THERE. IT HAS LONG BEEN A FIXED IDEA THAT ONLY A PITH HELMET WILL PROTECT ONE FROM THE SICKENING GLARE OF THE SUNLIGHT OF THE GOLD COAST, WHICH HAS THE LOCAL REPUTATION OF BEING MUCH MORE DEADLY THAN THE SUNLIGHT OF THE ORIENTAL TROPICS.

Euphorbia resinifera IN BLOOM ON THE HILLSIDES NEAR DEMNAT, MOROCCO. THEIR MASSES OF YELLOW FLOWERS CAN BE SEEN A HALF MILE AWAY AND ALTOGETHER THEY FORM ONE OF THE MOST STRIKING PLANT SIGHTS IN MOROCCO. THE LATEX OF THIS SPECIES IS HORRIBLY ACRID AS MY SON, GRAHAM, ACCIDENTALLY FOUND OUT. DR. W. M. WHEELER AND GRAHAM FAIRCHILD COLLECTING INSECT VISITORS TO THE FLOWERS.

introduction, for, although it might be supposed that a plant which once finds its way from the wilds into a European botanic garden is really "introduced" into general culture, this is really not the case. There are hundreds of species represented by single specimens in botanic gardens which are utterly unknown to the so-called nursery trade, much less to American amateurs. Only actual visits to these old mines of living plant material can disclose their existence, for often species that do poorly in the cooler moister summers and milder winters of Europe are the very ones which do best in the hot-summer-cold-winter climate of America. What is a virtual failure in Europe, one which would not be mentioned in any European literature, may prove a great success in America.

Several hundred species of plants were selected in European gardens and through the courtesy of the directors the expedition sent them in to our Washington greenhouses and propagating gardens where they will be increased for later distribution to the amateurs of horticulture in America. Acknowledgment of these courtesies will appear in print in the literature in which each various plant introduced is described officially. The standing offer which for thirty years has been operative, that of sending to any garden or other reputable institution abroad new plant material which is asked for from our own collections, may be expected to return these many courtesies shown to me by the botanists and horticulturists of the many countries visited by the expedition.

A stock of seeds of certain interesting new plants was, furthermore, carried on the yacht and distributed wherever the climatic and other conditions were right for their successful growth; so that the work of plant introduction as a result of the expedition's activities will be in no way confined to America or American territories.

The Argan Tree of Morocco

One of the interesting investigations carried out was that relating to the Argan tree of Morocco—a dry land tree

of the *Sapotaceae* which occurs in only one limited area of the world—that of Western Morocco. Here it forms great open forests covering about a million acres of territory. The extreme drouth resistance of the tree, the fact that its fruits, young branches and foliage make of the Argan trees, twenty feet above the ground, is one never to be forgotten by any one who has seen it.

Although its cultivation, like that of the Mediterranean Carob, offers little immediate prospect of commercial exploitation in Southern California, the

PROFESSOR RENÉ MAIRE, AUTHORITY ON THE MOROCCAN FLORA, AND MR. DURAND, WITH ARMED GUARDS, BOTANIZING UNDER THE BLOCK HOUSES WHICH OVERLOOK THE RIFFIAN BORDER NEAR OUEZZAN, MOROCCO. THIS TERRITORY HAD NEVER BEEN BOTANIZED OVER BEFORE BY ANY EUROPEAN BOTANIST. WE FOUND SEVERAL NEW FORMS, DISTINCT FROM THE SPECIES, WHICH OCCUR IN OTHER PARTS OF THE MEDITERRANEAN BASIN. THE RARE *Narcissus elegans* WAS SECURED HERE AND SENT TO AMERICA.

excellent forage for goats and cattle and that its seeds furnish a cooking oil has retained this unique slow growing tree (*Argania sideroxylon*) in the dry land agriculture of a remarkable agricultural race—that of the Berbers. The sight of herds of goats browsing in the very tops beauty of the tree itself and its astonishing resistance to drouth, make it very desirable that it be added to the shade and landscape trees of the dry hillsides of that state. Utilization of its stony hard seeds and its foliage may be left to another generation to determine.

The Retama as a Sand Binder

Among the sand dunes which before the French occupancy of Morocco threatened to overwhelm the old town of Magador there are growing certain extremely tenacious rapidly growing legumes whose root systems have retained the sand and whose broom-like branches cut for the purpose have been used by the French forestry officials to bind the shifting sands. These Retamas (*R. Bovei* in particular) may perform the same useful purposes when grown on the troublesome sand dunes of the Pacific slopes. They are attractive when in bloom, and since their flowers exhale a delicate fragrance they may prove of not only commercial but esthetic importance in America. They are already used for forcing purposes in Southern France and one sees them on the Paris flower market.

Morocco a Plant Paradise

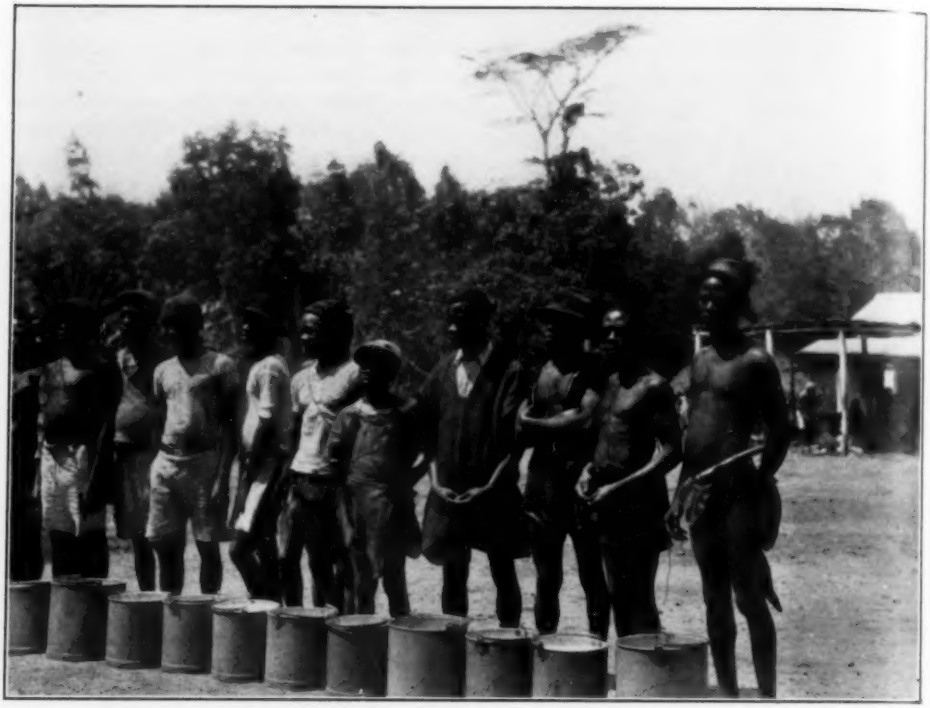
Morocco, which in itself proved one of the most fascinating collecting regions visited by the expedition, was made much more so by the courtesies of Professor René Maire, the authority on its flora with whom we were able to make several most interesting excursions—one in particular to the virgin botanical territory of Ouezzane (just before the recent outbreak of the Riffians), where no European botanist had yet been.

The cork forest of Marmora with its unbelievable wealth of bulbous plants and its soil so pliable that a slender dry grass halm can be thrust into it eight or more inches with ease, would repay any bulb collector to visit. He should be there in April. Any botanist would be fascinated by the rich alluvial river bottom of the Oued Sebou (?) where the Lavateras, Borages, Calendulas and wild mustards made a show of color more remarkable than any bedding out plants in any park I have ever seen; the rock outcrops of Socrat en Nemra in whose crevices grow all sorts of rare species of legumes and bulbous plants and at whose base occurs the original wild species of *Pisum* from which the cultivated pea originated; and *Linum angustifolium*, the flax of the Swiss lake dwellers. In the shade of the giant Atlas Cedars of Azru Professor Maire discovered a few years ago that remarkable species of Cytissus (*C. Battandieri*) which resembles nothing I can imagine unless it might be a golden flowered lilac with leaves which are covered with even softer, silkier hairs than those of the famous *Leucodendron argenteum* of Table Mountain, South Africa. Thanks to its discoverer, Professor Maire, seeds of this rare and beautiful shrub have been sent to California to grow there beside the Deodars and Atlas cedars of California gardens, and where already a tiny Leucoium, which we found in the forest of Marmora, is growing and blooming.

The Canary Islands

The Barrancos of the Canary Islands furnished some interesting forage plants; *Sonchus leptocephalus*, with a strange mouse odor of which the goats are very fond and an ability to establish itself in the arid almost barren rocks; *Cytissus proliferus*, the "Tagasaste," a leguminous cultivated crop; *Psoralia bituminosa*, also leguminous, the so-called "tedera" of the goat herders who scatter its seeds wherever they go over the hillsides because of the luxuriant growth of forage which it produces in early spring; and the "Gacia" (*Cytissus stenopetalus* var. *sericea* Pitthard), which is more limited in its uses than the Tagasaste, were some of the more useful plants found of which seeds were obtained.

The volcanic island of Lanzerote is the strangest island of the archipelago. It is an almost rainless island and parts of it



The problem of rubber production in West Africa seems to be as much a problem of labor as it is anywhere else. These tappers, with their pails of latex, have just come in from the Firestone rubber plantation in Liberia. They represent eight distinct tribes speaking eight dialects, yet they seem to be able to collect the rubber, though with how much profit to Mr. Firestone remains for his excellent organization to demonstrate.

are covered by a deep layer of cinders which were thrown out by its "Volcan de Fuego." Delicious grapes are grown in special pits dug in the cinders which collect the dews from the low blanket of clouds which covers the island nearly every night. A true brachitic dwarf maize not over two feet high is grown in the dew wetted cinders, but it takes as long to ripen its single ear of corn as an eighteen-foot corn stalk does to ripen its ears in the Kaw Valley. What it will do in other cool foggy climates remains to be seen.

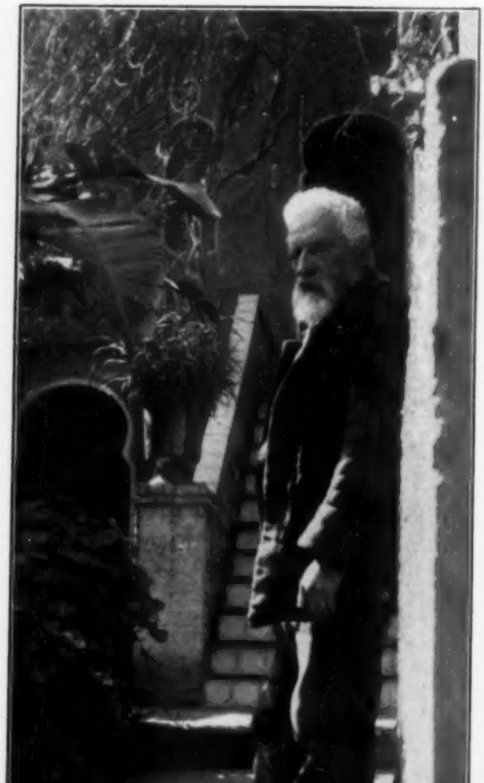
Whether the handsome Canary Island *Juniperus cedrus*, with its drooping branchlets, will be hardy anywhere on the Pacific coast or in Florida may require many trials to determine. As it is becoming rare in the Canaries it should be planted in other regions before it becomes extinct.

Some of the unique giant Aeoniums like *Aeonium tabulaeforme* with its great golden yellow inflorescences and dinner-plate-like rosette of leaves which grow on the perpendicular walls of the barrancos; the gorgeous blue *Echium pininana* with spikes twelve feet high and the handsome *Statice arborea*, to say nothing of the Giant Dragon's Blood tree, are among those plants of the Canaries which may be given a trial in California and Florida as a result of the expedition's collections.

A Tomato from the Balearic Islands

What are probably the best of the dried tomatoes on the Spanish markets are of an especially uniform variety grown on the slopes of Majorca at Banalbufar, on the remarkable terraces for which the island is noted, and dried there in special drying houses before being shipped to Spain. If this variety should prove adapted to the needs of the tomato growers of America, it may become a valuable addition to the varieties grown in this country, for its uniformity, brought about by selection, is remarkable and the fruit remains attached to the stem in the drying process—

HEAD MEN OF THE VILLAGE OF BROFUEBRU, ON THE GOLD COAST, STANDING IN A PATCH OF A SPECIES OF TALINUM WHICH HAS ALMOST OVERRUN THEIR GARDEN. THIS VEGETABLE IS ALSO MUCH USED IN CEYLON WHERE THE SINGHALESE LIKE IT IN THEIR CURRIES AND IT IS NOW BECOMING POPULAR IN FLORIDA AS A SUMMER GREEN VEGETABLE.



THE VETERAN PLANT INTRODUCER OF ALGERIA, DR. L. TRABUT, STANDING IN THE COURTYARD OF HIS RESIDENCE AT 7 RUE DES FONTAINES, MUSTAPHA, WHERE HE HAS WORKED FOR OVER THIRTY YEARS. THROUGH HIS REMARKABLE PLANT INTRODUCTION GARDEN HE HAS BROUGHT TO THE ATTENTION OF THE HORTICULTURAL WORLD A MOST UNUSUAL NUMBER OF NEW AND USEFUL PLANTS. HE HAS A PASSION FOR DOMESTICATING AND HYBRIDIZING WILD SPECIES IN WHICH HE DISCOVERS AGRICULTURAL POSSIBILITIES.

unlike many varieties which drop off when hung up by the stem.

The Slow Exchange of Cultivated Plants in the Tropics

So many centuries have elapsed since Europeans first visited the tropical regions of the western hemisphere that we are prone to think of the cultivated plants of the Oriental Tropics as having had ample time to find their way into use in the Occidental Tropics. This is a great illusion and one which arises from man's ignorance of the difficulties encountered in taking a living tropical plant half way round the world. The seeds of many tropical plants are very short lived. If dried they die and if kept moist they germinate in a few days, so that the only way to send them is as seedlings in Wardian cases. From Singapore to Panama by the fastest mail route is to-day about two months and there are few things in nature which are deadlier to tender young plants than salt spray. So that when a delicate seedling of some especially valuable Oriental plant starts on a journey towards South America it has rather poor chances as a rule of arriving alive. Every exchange of letters between the two countries takes months out of the lives of those interested in the introduction, and the few horticulturists living in the Tropics who are interested in plant introduction change their posts frequently. When this fact is taken in connection with that of the delayed correspondences, it is easy to understand why so many plants in one part of the tropical world are unknown in another. Then, too, the picture which one is apt to form of the tropical world being filled with men who are studying the uses of plants and trying to find out new ones is utterly unwarranted by the facts, for if the botanists of the whole tropical world were to gather together they would not

form a very impressive assembly, and they could easily be accommodated in the dining room of a small town hotel. Invention and research have scarcely yet touched the confines of the tropical world, even though exploitation is destroying fast the forests which harbor thousands of forms of unknown potentiality. With the opening of the highway overhead will come, let us hope, a quicker plant exchange from continent to continent.

North Sumatra

Sumatra with its ten thousand species of plants, is full of new "plant possibilities," but to get them out and over to the western world will require many years and many expeditions—and yet it is only one of the many richly forested islands which compose the Dutch East Indies.

Leguminous cover crops, new and as yet untested fruit trees, wild relatives of citrus fruits, magnificent new shade trees for tropical roadways, rapidly growing timber trees, and trees yielding gums and tannins and drugs abound in it, but as yet their value is too little known to make their introduction into our American tropics a matter of great popular interest.

However, the Merkus pine (*Pinus Merkusii*) is an exception, for plantations of it are being started in Atjeh and from it Mr. Brandts Buys has obtained a superior quality of turpentine by certain improved methods of tapping. This might develop into a plantation industry of such dimensions as to command the attention of American turpentine manufacturers. Its cultivation on a gigantic scale in the mountainous regions of the Tropics might even become the chief source of turpentine in the next century.

What man may require to-morrow to cater to his new tastes and contribute to his new playthings we have no way of surmising, but the example of rubber

Dr. William Morton Wheeler in a moment of triumph. He had just discovered the remarkable dipterous insect, Vermileo, which builds craters like those of the ordinary ant lion in the dust covering the floor of a hole in the rocks. Majorca, Balearic Islands.

and gutta percha, cocoa and sugar ought to make us careful with our predictions, for almost every change in the world of invention is reflected in the world of raw products and the tropical world is that world.

The Bamboos of Java

We are accustomed to associate bamboos with China and Japan, where large groves of at least three species do occur

IT IS RARE TO FIND A TREE WHICH IS CONFINED TO SO SMALL A REGION AS THIS ARGAN (*Argania sideroxylon*), WHICH OCCURS ONLY IN MOROCCO. BACK OF MOGADOR THE ARGANS ARE SCATTERED OVER THE DRY PLAINS LIKE ORCHARD TREES AND, ALTHOUGH THEIR FRUITS ARE HORRIBLY ACRID AND THEIR BRANCHES COVERED WITH SHORT SPINES, THE COUNTRY IS SO DRY THAT THEIR FOLIAGE AND FRUITS ARE OFTEN THE ONLY FOOD AVAILABLE FOR GOATS AND CATTLE. THE BERBER WOMEN MAKE A TABLE OIL FROM THE SEEDS AFTER THEY HAVE PASSED THROUGH THE INTESTINES OF THE ANIMALS.

and where a great use is made of them, but after my third visit to Java I am convinced that the Javanese rather than the Chinese or Japanese are the greatest employers of bamboo in the world. In China and Japan one sees innumerable field and household utensils and furniture made from bamboo, in Java as a general rule the houses themselves are made substantially of bamboo. The walls, the floor joists, the rafters, the flooring and often the roofs themselves are made of bamboo. I imagine there are in the neighborhood of 7,000,000 bamboo houses in Java alone, housing a population of 35,000,000. The Javanese live in bamboo houses and this can not be said of the Chinese or Japanese. Notwithstanding this great use of bamboo by the Javanese, one sees few large groves of bamboo in Java. The explanation lies in the fact that each householder grows his own small clump in his own yard and that in place of growing a species of the genus *Phyllostachys*, which has creeping or running rhizomes, they cultivate three caespitose species which are clump but not grove-forming and belong to the genera *Gigantochloa* and *Dendrocalamus*. The most important species are *G. Apus*, the "Tali" bamboo, a non-edible species of large size, the culms of which are used for making bridges, rafters, etc., and when split, for tying material; *G. Verticillata* "Andong," used extensively for making the mats or "Bilikken," which form 99 per cent. of the walls of the Javanese houses; *G. Asper*, Backer, the "Betong" bamboo, which is the largest of the Javanese species and that of which the young shoots are most used for food.

These bamboos strike me as distinctly cultivated plants, which have been in

culture in Java for many centuries. They have culms that rise perfectly straight from their rhizomes and without a curve attain a height of twenty to twenty-five meters, and unlike so many tropical bamboos have no short spiny branches near the ground. As compared with any other species of bamboo I have ever seen they appear to be far the most useful of all for tropical house building. Their introduction and popularization in the tropics of the Western Hemisphere and West Africa should long ago have been carried out. They split easily; their thin strips make remarkable tying material and they lend themselves to a vast variety of uses and should be grown in every native dooryard in the Tropics.

I believe their use would be likely to eliminate many of the other species with which I have become familiar and whose introduction into the Western Tropics so far has been attended with only a modicum of success. Even that giant bamboo, *Dendrocalamus gigantea*, far famed through the splendid hundred-foot-high clumps in the Peradeniya Gardens in Ceylon, is a distinctly less useful form. In Ceylon, in fact, little use is made of bamboo as compared with the extensive use made of it in Java.

Relatives of the Breadfruit

When Lieutenant Bligh, of the famous ship *Bounty*, brought the breadfruit to the West Indies from the South Sea Islands, I doubt if he would have even looked at its relative, the Jack-fruit tree. Yet to-day in Ceylon it is this Jack-fruit and not the famous breadfruit which has come to form the second most important food plant grown in that tropical island. The "Honey Jack," which produces its enormous twenty-five pound fruits borne on the tree trunk, deserves a special study by tropical agriculturists, for not only do its large seeds form a nutritious concentrated protein food, but the golden yellow arillus surrounding the seeds is so delicate and sweet that it forms one of the most sought-after delicacies of the Singhalese menu. The unripe fruit also forms an

CAMEROON MOUNTAIN WHICH RISES OVER THIRTEEN THOUSAND FEET ABOVE SEA-LEVEL AND IS THE HIGHEST ELEVATION ON THE WEST COAST OF AFRICA. BELOW ARE SHOWN THE OIL MILLS AND OFFICES OF THE GERMAN COMPANY WHICH IS ACTIVELY DEVELOPING ITS PLANTATIONS AFTER THE FORCED INACTIVITY RESULTING FROM THE WAR. THESE PLANTATIONS ARE PROSPERING UNDER THE BRITISH MANDATE. THE WEALTH OF PLANT FORMS TO BE SEEN IN THE JUNGLES OF THE CAMEROON ARE SURPASSED ONLY BY THOSE OF THE RICHER MALAYAN REGION.

GATHERING SEEDS OF THE WEST AFRICAN OIL PALM (*Elaeis guineensis*) FROM AN OLD SPECIMEN IN A CACAO ESTATE IN THE CAMEROON. THE OIL PALM OF WEST AFRICA IS THE MOST IMPORTANT FOOD-PRODUCING PLANT OF THAT REGION AND ITS OIL IS ONE OF THE MOST VALUABLE OF THE VEGETABLE OILS. THIS PALM IS DESTINED TO PLAY A MOST IMPORTANT RÔLE IN THE DEVELOPMENT OF THE TROPICS.

important constituent of their curry. The Honey Jack is a special variety, far superior to common seedlings.

Furthermore, as a tropical timber tree it ranks so high that the Ceylon Forestry Department is urging its planting on a large scale. It has soft easily workable wood containing a brilliant yellow dye.

The whole Genus Artocarpus, comprising sixty species, deserves to be more widely known, for it contains besides the breadfruit and the Jack-fruit trees, *A. falcatum*, *A. Champeden*, *A. lakucha*, *A. elastica*, *A. gomeziana*, *A. rigida*, *A. polyphemia* and *A. odoratissima*, all superb trees with edible fruits which as yet have been in no way selected for quality. *A. Nobilis* and *A. lancaefolia* are two superb species not having edible fruit, but useful as avenue or shade trees in tropical gardens. In South Florida several species have already shown themselves remarkably well adapted to the limestone soils there.

Casuarinas, the So-called She Oaks or Australian Pines

The so-called She oak or Australian pine, *Casuarinas equisaetifolia*, has played a great rôle in most tropical lowlands near the sea. It is to be seen on almost any seashore from Florida to Celebes, but there are rarer and more attractive species than the common one and their introduction deserves consideration. Seeds of *C. Sumatrana*, *C. montana*, *C. suberosa* and *C. Rumphiana* were secured and sent in by the expedition. The fact that hybrids between certain of these species have been found in Algiers makes it likely that there could be produced by breeding forms which would grow even more rapidly than the phenominally rapid growing species, *C. equisaetifolia*, and have a much more attractive form. The success of Dr. Trabut's hybrid Eucalyptus in Algiers (*E. Trabuti*) might be paralleled by that of some hybrid casuarina. The wood of this rapidly growing tree known as Beef Wood in Australia has not yet come into its own as a timber, although it makes exceptionally durable tool

handles. As a fire wood it is distinctly valuable.

Terrestrial Orchids for Tropical Border Gardens

To find a terrestrial orchid of easy culture which might be depended upon to beautify the private gardens of our extreme South has always been a special desire of mine and while in Ceylon and Singapore my attention was particularly attracted by the two species of Arundina, *A. Chinensis* and *A. Bambusaefolia,* whose grass-like stems rising several feet in the air bear small but very beautiful Cattleya-like flowers that are very attractive indeed.

Dr. Trabut called my attention to *Orchis robertiana,* which grows commonly in Algiers and which from his experience is one of the easiest of all to be grown in borders. We saw *Orchis papilionacea,* a terrestrial species of real beauty, blooming back of Amismiz, in the Atlas Mountains of Morocco. It was growing wild in the dry soil which baked as hard as brick and it seemed as though it should grow easily in the gardens of California.

In the pine forest (*Pinus Merkusi*) of North Sumatra, I saw growing for the first time the glorious ground orchid five feet high, *Phaius tankervilliae,* which the literature reports as one of the first plants to be imported from the Dutch East Indies into European greenhouses. Its culture might add great beauty to Florida landscapes.

As we rode from Accra to Winneba last February through the low Savannah which fringes the Gold Coast we saw patches of that superb ground orchid, *Lissochilus Heudelottii,* which grows to four and a half feet in height and has purple-lipped flowers as beautiful as small cattleyas. Its tubers resemble new potatoes and are produced in short chains three or so in a chain. Since the Accra Plain is subjected to extreme summer drouths it would appear quite possible to acclimatize such a species as this in the warmer parts of California and South Florida.

THE WONDERFUL PALMYRA PALM (*Borassus flabellifer*), WHICH SURPASSES THE CABBAGE PALMETTO OF FLORIDA IN STATELINESS AND WHICH WILL PROBABLY GROW AS WELL IN SOUTH FLORIDA AS IT DOES IN THE JAFFNA REGION OF NORTHERN CEYLON. GROVES OF IT ARE AS BEAUTIFUL AS GROVES OF THE DATE PALM IN EGYPT.

But the handsomest of all the terrestrial orchids which I have ever seen was a species blooming in the conservatory

Artocarpus champenden, ONE OF THE LITTLE-KNOWN RELATIVES OF THE BREADFRUIT AND JACKFRUIT TREES, WHICH IS CULTIVATED IN THE SINGAPORE REGION AND SOLD ON THE MARKETS THERE, BUT WHICH HAS NEVER BEEN GROWN SO FAR AS I KNOW IN THE WESTERN HEMISPHERE.

of the Botanic Garden in Munich, which Professor Goebel showed me last June (*Sobralia macrantha*), from the Indo-Malayan region. Its immense cattleya—like deep pink flowers, although wilting too quickly to make it useful for cut flower purposes, might make it a species of the greatest interest for out-door culture in our extreme South and in tropical regions generally.

Citrus Fruits and Citrus Regions

The following very brief notes on citrus regions and citrus fruits have been collected during the past three years of travel. They may prove of interest to citrus growers and are represented by photographs in my albums of travel.

The commercial orange culture of Bou Farik in Algiers is that from which the Paris market gets part of its supply of oranges. It produces exceptionally fine-flavored dark-colored tangerines and sweet oranges. Dr. Trabut's new Bigaradier "orange à confiture" with a thick rind, making it valuable for marmalade purposes; and his Limoncello, seedless lime from Palermo, also worthy of our study, is a new possibility. The beautiful oranges of the region about Port Say, Northern Morocco, were disappointing so far as flavor was concerned. The spotless orange trees in an isolated Arab Patio in Ouezzan, where no European disease had yet penetrated, was a striking illustration of the fact that plants can be protected from disease by isolation.

The famous oranges of the little village of Telde in the Island of Grand Canary—so noted that a special tree was kept loaded with its beautiful fruits for the Duke and Duchess of York to see, I found particularly attractive with no "rag," kidgloved, beautiful skin, very juicy and not too sweet. These Telde oranges I am told bring a fancy price on the London market.

A to me extremely interesting and seemingly disease-resistant relative of the orange was *Atalantia missionis*, which I saw growing in the Regent's Park in Jaffna, Ceylon, and it ought certainly to be tested as a stock for citrus fruits. Because of its superb ornamental appearance alone it is worth introducing. Its foliage was spotless and scaleless and hundreds of seedlings were growing under the tree.

To stumble upon a large wild citrus tree, as Mr. Dorsett did, in the very heart of the jungles of Atcheen, and

later find fruit of what looks to be the same species for sale in a mountain village market near Takengon, N. Sumatra, was an exciting experience, even though the fruit was too aromatic to be good to eat and was only used by the natives for washing their hair. I judge it to be a wild relative of our grape fruit. Seedlings from a fruit sent to Washington are now growing there.

To tear open a Javanese pink-fleshed shaddock is a delightful experience and sooner or later our American tables should be supplied with the best of these fine Javanese shaddocks, since living seedlings of the best varieties are now growing in America. The deep pink color of the fruit flesh would add a very attractive touch to our fruit salads.

Mr. Ochse, of the Department of Agriculture in Buitenzorg, Java, gave us seeds of what he is pleased to call the "Japanese citron," which he discovered in the native Kampongs or villages of Java and which has proven a remarkable stock for the very wet lands of Western Java. This may prove of value as a stock for Panama and Honduras. The so-called Kaffir Lime (*Citrus Acida*) of North Sumatra which is used as a head wash by the natives may also prove valuable as a citrus stock somewhere.

But perhaps the most unexpected of the citrus relatives seen by the expedition is the tree furnishing the so-called "Curry Leaf" of Ceylon (*Murraya Koeningii*), of which one finds fresh leafy twigs for sale in every large market in the island. The use of the fresh leaves of this close relative of the orange Jasmin (*Murraya exotica*) seems to be almost universal in Ceylon and to it may be ascribed the characteristic oriental flavor of the Ceylon curry. Its culture in South Florida should be easy and it ought to enter the list of our flavoring vegetables. We use the laurel leaf of the Mediterranean region; why not the curry leaf of Ceylon? One sees beautiful oranges in March on the Malaga market in Southeastern Spain, but none that appeared to me unusual enough to deserve to be experimented with. They represent the Valencia-grown varieties.

—*Photo by J. H. Dorsett*

DR. BRANDTS BUYS HAS DEVISED THIS METHOD OF GATHERING THE TURPENTINE OF THE TROPICAL PINE (*Pinus merkusii*) IN NORTHERN SUMATRA. HE BELIEVES THE NEW TECHNIQUE IS A GREAT IMPROVEMENT ON METHODS USED IN EUROPE AND AMERICA AND EXPECTS IT TO GIVE THIS TROPICAL TURPENTINE-BEARING PINE GREAT POSSIBILITIES AS A PLANTATION CROP.

Of orange culture in the West African colonies the best fruits I saw were among the Fulla tribes of the Fouta Djallon Mountains of French Guinea.

TWO OF THE REMARKABLE CULTIVATED BAMBOOS OF JAVA, THE "BETONG" AND THE "TALI" (*Dendrocalamus asper* BACKER, AND *Gigantochloa apus* KURZ). OUT OF THE CHARACTERISTIC TIMBER OF THESE TWO BAMBOOS MORE THAN THIRTY MILLION PEOPLE BUILD THEIR HOUSES IN THE ISLAND OF JAVA. THEY SHOULD BE PLANTED WHEREVER THEY CAN BE GROWN IN THE TROPICS OF THE WESTERN HEMISPHERE.

The juiciness and high flavor of the fruits sold to me (fifteen for a French franc, four cents) by natives of this tribe make it seem quite possible that in these remarkable mountains a citrus culture may be developed which will reach Europe with its products. I was not favorably impressed by any of the citrus fruits I saw in any of the other West African colonies and upon what grounds the hope of a great citrus culture in any of them is based, I do not understand. I believe citrus culture will for a long time to come be largely a matter of the control of the diseases which molest the trees.

Mango Varieties and Stock Species

I was much disappointed not to discover any mango varieties in Ceylon, Java, Sumatra, Singapore, Penang or West Africa which are particularly worthy of the attention of Florida growers. It was not the mango season, it is true, but I studied the colored drawings of the varieties grown in Ceylon and Java and interviewed every one who would be likely to know about mangos and nowhere could I get trace of a variety so showy as the Florida "Hayden." I was unable, however, to visit British India or Burma, where the best of our collection of mangos now in Florida came from. Perhaps there are forms in the gardens there better than those we have already imported and are growing in Florida. In the highlands of North Sumatra we saw a single giant mango tree of unbelievable size but poor fruit. It stood on the shores of Lake Tawar and remains in my memory as one of the most beautiful trees of any species which I have ever seen. In East Java I studied the newly started mango collections of Dr. Oehse and saw the excellent watercolor drawings of Mr. E. de Vries, but found no single variety as showy as the Hayden. All mangos there are propagated by inarching. That some of the Javanese varieties will do better in wet regions than our Florida varieties have done, I am prepared to believe and that the stock mangos "Nanas" and "Kopior" adapted to alkaline soils may prove extremely valuable in American mango culture, I think quite probable.

In Egypt on the islands in the Nile a mango industry has grown up since I was first there in 1902. This seems to be built upon the basis of a single small fiberless variety of good quality, trees of which I saw in Prince Mohamet Ali's garden in Cairo.

Nowhere have I ever seen such mango *avenues* as those at Konakry in French Guinea. For miles these glorious avenues of mango trees loaded with their young fruits stretched away from the town into the country. The streets were wonderfully shaded by these trees which had been planted by the noted governor of the colony, Governor Ballay, to whose memory they form a fitting monument. Why many other places have not used the mango as a shade tree I find it hard to understand. Fear of the fruit falling on the roadway appears to be an ungrounded objection to it. South Florida should follow Konakry's example and plant an avenue of mango trees a mile long. The mango fruits from these seedling trees are fibrous but have a pink blush and are of good flavor—better than our "turpentines" it seemed to me. The French have a few grafted forms but none of outstanding quality. Why nowhere in West Africa the fiberless East Indian mangos are grown I can not comprehend.

The seeds of two relatives of the mango, *Mangifera foetida* and *Mangifera odorata*, which we bought on the Singapore markets, may, because of their rapid growth, be useful as a stock for the mango itself.

The Rubus Species of the High Altitudes in the Tropics

With the gathering of European residents in the higher altitudes of the Tropics has come into existence as interesting new problem—that of supplying them with raspberries. The number of remarkable species of Rubus which one sees in the mountain regions of Ceylon, Sumatra, Java and Africa, not to mention the enormous fruited forms of Colombia and the Hawaiian Islands, would seem to hold out to the breeder a fascinating possibility in view of the successes which have attended the improvement of the genus by breeding and selection in temperate regions.

The expedition collected over thirty species of Rubus from the mountains of the Oriental Tropics, but until some plant breeder establishes himself in the mountains of the tropics little will come, I presume, from their cultivation.

WILD PLANT OF *Nicotiana glauca* GROWING NEAR TELDE, GRAND CANARY. DR. H. H. MCKINNEY, WHO IS SHOWN IN THE PHOTOGRAPH, DISCOVERED THREE TYPES OF MOSAIC SYMPTOMS ON THIS PLANT, A DARK GREEN, A LIGHT GREEN AND A YELLOW TYPE, THE LIGHT GREEN BEING THE MOST PREVALENT AND APPARENTLY IDENTICAL WITH THE MOSAIC FOUND ON TOBACCO IN THE UNITED STATES. HE ISOLATED THE YELLOW TYPE FROM THE LIGHT GREEN TYPE BY MEANS OF HIS SPECIAL CENTRIFUGAL APPARATUS.

Relatives of the Banana

Although the literature led me to hope that the expedition might find many species of Musa related to the banana only two were actually secured worthy of note. *Musa Glauca,* which was given me by M. Loerzing, the remarkable director of the plant garden at Sibolangit in North Sumatra and a wild undetermined dark-stemmed slender form with small seedy fruits from the

jungles near Takengon, Sumatra. *Musa Glauca* with its large glaucous trunk, which is swollen at the base, makes a most attractive ornamental for garden decoration and the wild form which I found near Takengon may have value for breeding purposes.

Of the numerous African species I was able to find no material during the short stays made by the expedition on the West Coast.

Drug and Poison Producing Plants

One of the famous arrow poisons of West Africa is produced by the natives from the seeds of *Strophanthus sarmentosus,* which is a handsome flowered liana growing over the tops of tall forest trees pretty much throughout West Africa. Strophanthin is one of the most powerful heart poisons known and is secured from several species of the genus, but so far as I know none of these species has been cultivated. Ordinarily as one sees the vine in bloom it does not strike one as so particularly beautiful, for only a comparatively few flowers are produced at a time, but as we saw it back of Chief Oumarous' Compound at Dalaba in the Fouta Djallon Mountains of French Guinea, where it had been given some care by the chief who knew well of its poisonous character, it appeared as a most attractive flowering vine with its large cream white flowers, each with long tapering pennant shaped petals, with a purple base. If for no other reason than that of its beauty, it deserves to be cultivated in tropical gardens throughout the world. Furthermore the value of its seeds as a source of strophanthin should not be overlooked in its culture. Should it come into cultivation, as the result of the seeds sent in by the expedition, the credit for its introduction ought to go to Dr. Dalziel, who for years has studied its occurrence in Nigeria and was the first to describe the process by which the natives of Nigeria prepare their arrow poison from its seeds.

I saw a specimen of its giant relative in Java, *Str. Gratus,* but no seed was ripe at the time of our visit.

The Zulu arrow poison is made from the bark of *Acokanthera venenata.* I found that its near relative, *A. spectabilis,* is being used as an ornamental tree in the gardens of the Canary Islands. Whether or not it contains the same poison I do not know, but the tree deserves to be widely grown because of its handsome foliage and fragrant flowers.

The "Bassa" of Lagos (*Tephrosia Vogelii*) undoubtedly contains a poison of some kind, for its leaves pounded up and thrown into a stream, which has been dammed for the purpose, kills fish in a few minutes and gives to the skin of the natives who wade in after the fish a "dead" feeling. Its general use as a cure for mange in dogs is attested by competent observers. Being a leguminous shrub capable of easy cultivation, its properties ought to be thoroughly investigated.

Picralima Klainiana, the fruits of which are used as a remedy for fever on the Gold Coast, probably contains an alkaloid. It is as handsome a shade tree as any I ever saw and deserves to be grown in tropical gardens.

New or Rare Tropical Fruits

Twenty-five species of fruiting trees or shrubs were selected and seed of them sent to America from the various regions visited by the expedition. I think they are nearly all new or rare in the Western Hemisphere. These include the remarkable Keppel Tree, favorite fruit of the Sultan's Harem in Djokjakarta, Java (*Stelecocarpus burahol*); the "Honey" variety of Jack-fruit already mentioned; an astonishing variety of coconut called the "Nawas," even the husk of which is crisp and sweet like a

THE ARCHITECTURE OF THE BATTAK VILLAGES OF SUMATRA IS DETERMINED BY THE MATERIALS AVAILABLE, AND THE PICTURESQUE AND CHARMING RESULTS PRODUCED BY THESE PRIMITIVE PEOPLE, WHO WERE CANNIBALS ONLY A GENERATION AGO, ARE THE DELIGHT OF THE TRAVELERS. MRS. FAIRCHILD AND MR. DORSETT ARE HERE SHOWN INSPECTING THE BAMBOO FRAMEWORK OF A COMMUNAL HOUSE NEAR KABANDJAHE, SUMATRA.

turnip; a superior Ceylon variety of the Bael Fruit (*Aegle marmelos*), which for generations has been used as a breakfast fruit by the Kings of Kandy, and which deserves to be thoroughly exploited as a fruit tree in South Florida; the "Ceylon Olive," *Elaeocarpus serratus*, which produces a palatable fruit for stewing and pickling purposes; the Lovi Lovi Tree (*Flacourtia inermis*) with its enormous crops of brilliant red acid fruits suitable for preserves; *Mimusops elengi*, a small fruit of the *Sapotaceae*, reminding one somewhat of the Sapodilla; the Miraculous Fruit (*Synsepalum dulcificum*) with fruits which make even the sourest lemon taste sweet for hours after eating it; three species of tropical Ficus with sweet, edible fruits as yet uncultivated and producing such masses of fruits that they must prove good bird food trees even if man does not utilize them; three species of the genus Dialium, called the Velvet Tamarind, whose remarkable jet black velvet fruits have an agreeable sweet acid flavor about them which will make them favorites at least among the children; the Baobab (*Adansonia digitata*) with its immense pods containing seeds covered with a chalk white arillus that resembles cream of tartar in flavor; *Balanites Egyptiaca*, the "desert date" of Senegal, a favorite of the natives of Fashoda, which, did it not have a curious bitter flavor about it, would be an excellent fruit for the Southwestern deserts of America; *Carpodinus dulcis* and *Alchornea cordata*, the "Christmas bush," two edible fruited species of shrub as yet unknown in the Western Hemisphere, I imagine, and too little known by Europeans to judge of their quality; together with two as yet undetermined new fruits which we found in Sierra Leone and the Gold Coast, re-

spectively. These make up the list of the outstanding fruit, tree and shrub introductions made as a result of the expedition. Years hence some at least will, I trust, have found a permanent home somewhere in America.

Palms

There are over 1,200 species of palm known and any expedition which would undertake to get living specimens of them together for some tropical arboretum would be undertaking a work of many years. I doubt if in any one spot in the world to-day two hundred species of living palms are to be found.

The seeds of palms are difficult to ship, which accounts for the fact that so few of the remarkable East Indian species are growing to-day in the Western Hemisphere. By removing all fermentable fruit pulp from palm seeds and replacing it with a layer of wax paper and then packing in very slightly moist finely pulverized peat we were able to land a fair proportion of our palm seed collection in Washington alive. The more interesting species included the Palmyra Palm of Northern Ceylon, *Borassus flabellifer,* and its related species, *B. ethiopum,* from the Gambia region of West Africa, both destined I trust to change the landscapes of South Florida. The *"Diwakawaka"* and *"Lisombe"* varieties of the West African Oil Palm, *Elaeis guiennense,* the two varieties from which, according to Yampowsky, the largest yields of palm oil may be expected if they can be established by selection; the famous branching Dum Palm of the Sudan, *Hyphaene thebiaca,* a landscape tree of great elegance; three varieties of the Betel Palm, *Areca catechu,* from Ceylon, where the habit

UNLESS ONE HAS TRIED TO TRANSPORT WARDIAN CASES THROUGH THE INDIAN OCEAN DURING THE SOUTHWEST MONSOON ONE HAS ONLY A FAINT IDEA OF THE DIFFICULTIES WHICH PLANTS HAVE TO ENCOUNTER WHEN STORED ON THE POOP DECK OF SOME PASSENGER STEAMER BOUND FOR NEW YORK. COVERING AND UNCOVERING THE CASES KEEPS THE SPRAY OFF OF THEM AND TO SHADE THEM FROM THE TERRIFIC TROPICAL SUN IS NOT SO EASY AS IT MIGHT APPEAR. GRAHAM TAKING OFF THE TARPAULIN ON A CLOUDY DAY.

—*Photo by H. H. McKinney*

DR. MCKINNEY GREW HIS OWN TOBACCO PLANTS IN SOIL FROM HIS OWN EXPERIMENTAL PLOTS AT ARLINGTON, VA., AND IN THIS WAY WAS ABLE TO BRING BACK WITH HIM MOST VALUABLE MOSAIC MATERIAL BY INOCULATING HEALTHY TOBACCO PLANTS WITH VIRUS OBTAINED FROM WILD PLANTS COLLECTED ON THE BARRANCOS OF THE CANARIES AND IN THE JUNGLES OF WEST AFRICA. THE SOIL WHICH HE BROUGHT IN ON HIS PLANTS WAS THE IDENTICAL SOIL WHICH HE TOOK OUT WITH HIM. THE PHOTOGRAPH SHOWS THE INGENIOUS WAY IN WHICH HE HELD THE PLANTS IN POSITION ON THE DECK OF THE YACHT.

of chewing the betel-nut seems to be on the increase in strong contrast with Java, where it appears to be on the wane; the unique Rattan Palm (*Pigafettia elata*) from the Moluccas, a most amazingly rapid grower, attaining a height of sixty feet in less than seven years—a palm deserving of much more attention for avenue purposes than it has hitherto received.

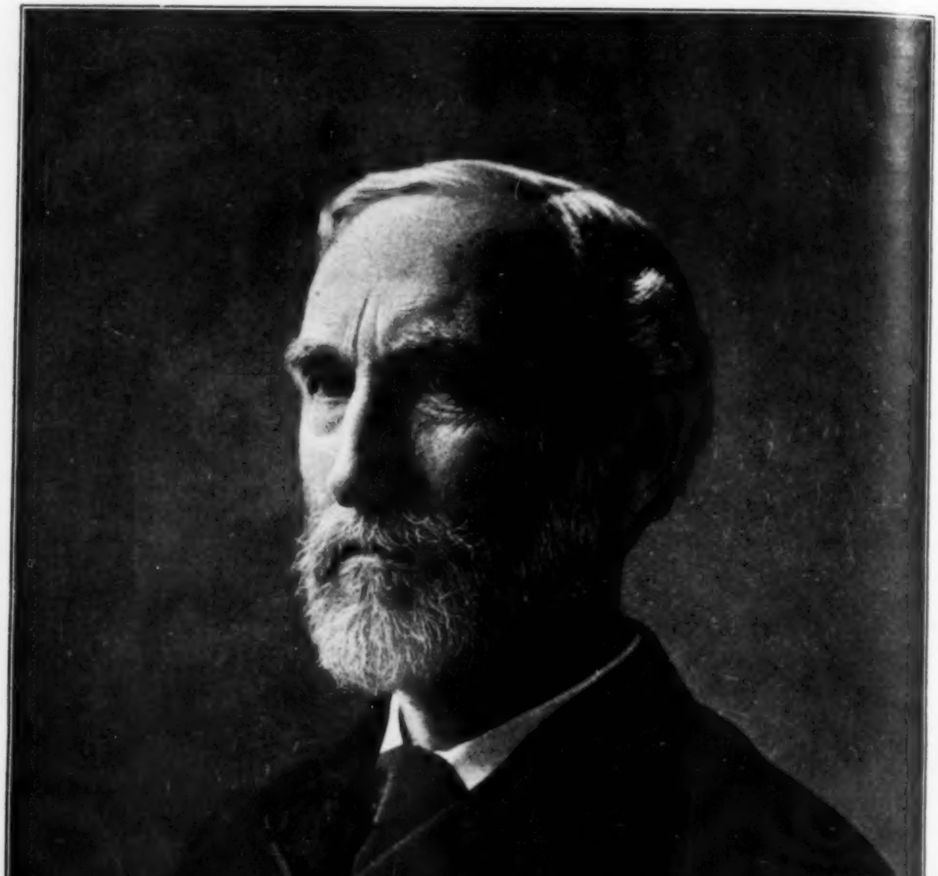
Another superb avenue palm which was sent in, a native of Malaya, was *Actinorhytis calapparia*, a species which requires for its full growth less than half the space that the Royal Palm does. The sealing-wax palm (*Cyrtostachys renda*), which is characterized by having the most beautiful scarlet colored leaf-sheaths imaginable, has become a common dooryard palm in the private residences of Medan, Sumatra. I thought it was the handsomest dooryard palm I had ever seen and secured as much seed as I could. The semi-aquatic Nipa palm (*Nipa fruticans*) had not yet been established on the coast of South Florida nor so far as I know anywhere in the whole Western Hemisphere, and I trust that the seeds secured may establish it there. It is a denizen of the brackish waters of the coastal plains of the Orient and is one of the most useful palms there. Why that incomparable palm of the Indo-Malayan Region (*Onchosperma filamentosa*) has not been widely naturalized in the tropics of the American

continents I do not know, for of all the graceful species of this peculiarly graceful order of plants they are among the finest. Their incomparably slender trunks, which grow in clusters of twenty or so, rise from bases which are not over six or eight inches in diameter to a height of fifty feet and bear at their tips long waving plumes of foliage.

When I read this brief catalogue of plants which the expedition collected, I am conscious that my enthusiasm regarding the various species may smack of "counting one's chickens before they are hatched," but nevertheless it is not a mere catalogue, for there are now hundreds of thousands of these small plants growing larger every day in pots or boxes or in rows in the various plant introduction gardens of the Department of Agriculture, and these will show in time what they are going to do in their new homes.

The Allison V. Armour Expeditions may not have very materially widened the horizon of the known, but they have made available to thousands of experimenters rare and valuable living plant material for experimental use which they could probably never have had otherwise. Out of some of these plants I am confident things of real wealth and use will come with the lapse of years.

The scientific observations on ants and other insects which Dr. Wheeler made in the Canaries and Balearic Islands have some of them been already published. The materials collected by Dr. McKinney, which have a direct bearing upon the obscure virus diseases of cultivated plants, have, I believe, already contributed valuable data for his researches, and the observations and collected materials which Dr. Dalziel made on the West Coast of Africa may be expected to be of distinct value in the completion of the Flora of West Africa upon which he is engaged.



J. WILLARD GIBBS

WILLARD GIBBS, AN APPRECIATION

By Dr. JOHN JOHNSTON
DEPARTMENT OF CHEMISTRY, YALE UNIVERSITY

It is somewhat of an anomaly that the fiftieth anniversary of the publication, in the *Transactions* of the Connecticut Academy, of the first part of Gibbs's great work on the equilibrium of heterogeneous substances should have been signalized in Holland by the publication of a Gibbs number of their chemical journal, the *Chemisch Weekblad;* whereas few, if any, in America took thought of the matter at all. It is furthermore anomalous that the contributors to this number should include besides the Hollanders (W. P. Jorissen, J. D. van der Waals, Jr., F. A. H. Schreinemakers, J. J. van Laar, J. W. Terwen), a Frenchman (H. LeChatelier) two Germans (W. Ostwald, G. Tammann), a Canadian (W. Lash Miller) a Norwegian (J. H. L. Vogt), two Englishmen (F. G. Donnan, F. A. Freeth), but no American. Truly a prophet is not without honor save in his own country.

This is instanced in another way. Quite a number of foreigners visiting Yale have asked about a memorial to Gibbs, and have expressed astonishment at the reply that there is none, apart from a bas-relief on the stairway of the Sloane Physics Laboratory,—and this bas-relief is the gift of Professor Walther Nernst, of the University of Berlin. One visitor, a distinguished Swedish scientist, was not satisfied until he had laid a wreath upon Gibbs's grave. This is a condition of affairs which, it is expected, will soon be remedied by the establishment at Yale University of an appropriate memorial in the form of a Willard Gibbs professorship. Those appointed to this professorship would, it is contemplated, be men from other institutions qualified to give a course of lectures, extending over one or two terms, in some branch of chemistry, physics or mathematics, particularly in those fields especially associated with the name of Gibbs; and they would be considered as temporary members of the faculty giving courses regarded as a regular part of the university curriculum. The rotation of eminent men, from many countries, each an outstanding figure in his own line of work, would serve as an inspiration to faculty and student alike, and thus would constitute a continuous and effective memorial to Gibbs.

At present one can merely adopt the epitaph to Sir Christopher Wren "Si monumentum requiris, circumspice," in suggesting that the visitor read Gibbs's papers and ponder their manifold practical consequences, both direct and indirect. But his most important papers are again out of print and difficult of access, as indeed they have been for a considerable fraction of the period since their first publication. This difficulty will soon be removed by the publication—arrangements for which are well under way—of an inexpensive reprint of his works. But another difficulty remains, for Gibbs's reasoning is so rigorous that few people have been willing to study his works sufficiently to grasp their full implications; for to him "mathematics is a language," as he is reported to have stated in a faculty meeting engaged upon the Sisyphean task of determining the course of study to be pursued by the average student. This difficulty of interpretation may, it is hoped, be alleviated by the publication of a volume, or volumes, in which his work would be amplified and explained, with illustrations of its application to some of the multifarious experimental cases which have in the meantime been investigated;

arrangements are now under way to have these essays written by those most competent in the special fields. This should serve to widen the appreciation of Gibbs's contribution to natural philosophy; for, particularly as regards many of the developments of great economic value, those who have benefited are quite unaware of the fact that without Gibbs's work these developments would not have been possible. Nor is it a case of which it may be asserted that some one else would have done it; this would be true with respect to isolated theorems, but only a genius of the first order could imagine and arrange the whole as a connected philosophy. It may well be remarked here that no mistake has yet been discovered in Gibbs's work—the accumulation of experimental observations has merely verified his predictions, and in no case run counter to them—though in the fifty years since publication many principles and theories of physical science then generally accepted as fundamentally true have proved to be incompletely valid or even erroneous.

Before endeavoring to set forth what was achieved by Gibbs let us recall the main facts of his life. Josiah Willard Gibbs was born in New Haven, February 11, 1839, the fourth child and only son of Josiah Willard Gibbs, professor of sacred literature in the Yale Divinity School, and of his wife Mary Anna, daughter of Dr. John Van Cleve, of Princeton. He entered Yale College in 1854, graduated in 1858, and continued his studies in New Haven until 1863 when he received the degree of doctor of philosophy, the title of his dissertation being "On the Form of the Teeth of Wheels in Spur Gearing."[1] He then spent three years as a tutor, the first two in latin, the last in natural philosophy, and in 1866 went to Europe, first to Paris, then to Berlin and finally to Heidelberg, where at that time both Kirchhoff and Helmholtz were active. In 1869 he returned to New Haven, and in 1871 he was appointed professor of mathematical physics in Yale College, a position which he held until his death, April 28, 1903. Scientific honors of all kinds came to him, degrees, membership in academies and other learned societies; and he was in correspondence with Kelvin, Clerk Maxwell, Boltzmann and other contemporary European leaders in mathematical physics.

In 1873, when thirty-four years old, he published in the *Transactions* of the Connecticut Academy two papers, one entitled "Graphical Methods in the Thermodynamics of Fluids," the other "A Method of Geometrical Representation of the Thermodynamic Properties of Substances by Means of Surfaces"; and, following these, in 1876 and 1878, the two parts of the great paper "On the Equilibrium of Heterogeneous Substances" which is generally "considered his most important contribution to physical science, and which is unquestionably among the greatest and most enduring monuments of the wonderful scientific activity of the nineteenth century" (Bumstead[2]). His subsequent principal writings, in the years 1881–1893, deal with multiple algebra and vector analysis (the latter finally published in 1901 as a treatise edited by Professor E. B. Wilson); with the electromagnetic theory of light, a series which appeared between 1882 and 1889; and lastly a work entitled "Elementary Principles in Statistical Mechanics," in which he returned to a theme closely connected with his work on thermodynamics. At his death were found a few fragments, intended as portions of a supplement to the "Equilibrium of Heterogeneous Substances"; these are published in the "Scientific Papers." It is of interest to

[1] This dissertation has never been printed; the original manuscript is preserved in the Yale Library.

[2] "The Scientific Papers of J. Willard Gibbs" edited by Henry Andrews Bumstead and Ralph Gibbs Van Name; 2 volumes, 1906. (Vol. I is now out of print.)

note that one of the topics he proposed to treat is "entropy as mixed-up-ness," a point of view which during the last few years has been widely adopted.

With respect to his personal characteristics I can not do better than quote from the biographical sketch prefixed to volume I of the "Scientific Papers."

Outside of his scientific activities, Professor Gibbs's life was uneventful; he made but one visit to Europe, and with the exception of those three years, and of summer vacations in the mountains, his whole life was spent in New Haven, and all but his earlier years in the same house, which his father had built only a few rods from the school where he prepared for college and from the university in the service of which his life was spent. His constitution was never robust—the consequence apparently of an attack of scarlet fever in early childhood—but with careful attention to health and a regular mode of life his work suffered from this cause no long or serious interruption until the end, which came suddenly after an illness of only a few days. He never married, but made his home with his sister and her family. Of a retiring disposition, he went little into general society and was known to few outside the university; but by those who were honoured by his friendship, and by his students, he was greatly beloved. His modesty with regard to his work was proverbial among all who knew him, and it was entirely real and unaffected. There was never any doubt in his mind, however, as to the accuracy of anything which he published, nor indeed did he underestimate its importance; but he seemed to regard it in an entirely impersonal way and never doubted, apparently, that what he had accomplished could have been done equally well by almost any one who might have happened to give his attention to the same problem. Those nearest him for many years are constrained to believe that he never realized that he was endowed with most unusual powers of mind; there was never any tendency to make the importance of his work an excuse for neglecting even the most trivial of his duties as an officer of the college, and he was never too busy to devote, at once, as much time and energy as might be necessary to any of his students who privately sought his assistance.

Although long intervals sometimes elapsed between his publications his habits of work were steady and systematic; but he worked alone and, apparently, without need of the stimulus of personal conversation upon the subject, or of criticism from others, which is often helpful even when the critic is intellectually an inferior. So far from publishing partial results, he seldom, if ever, spoke of what he was doing until it was practically in its final and complete form. This was his chief limitation as a teacher of advanced students; he did not take them into his confidence with regard to his current work, and even when he lectured upon a subject in advance of its publication (as was the case for a number of years before the appearance of the "Statistical Mechanics") the work was really complete except for a few finishing touches. Thus his students were deprived of the advantage of seeing his great structures in process of building, of helping him in the details, and of being in such ways encouraged to make for themselves attempts similar in character, however small their scale. But on the other hand, they owe to him a debt of gratitude for an introduction into the profounder regions of natural philosophy such as they could have obtained from few other living teachers. Always carefully prepared, his lectures were marked by the same great qualities as his published papers and were, in addition, enriched by many apt and simple illustrations which can never be forgotten by those who heard them. No necessary qualification to a statement was ever omitted, and, on the other hand, it seldom failed to receive the most general application of which it was capable; his students had ample opportunity to learn what may be regarded as known, what is guessed at, what a proof is, and how far it goes. Although he disregarded many of the shibboleths of the mathematical rigorists, his logical processes were really of the most severe type; in power of deduction, of generalization, in insight into hidden relations, in critical acumen, utter lack of prejudice, and in the philosophical breadth of his view of the object and aim of physics, he has had few superiors in the history of the science; and no student could come in contact with this serene and impartial mind without feeling profoundly its influence in all his future studies of nature.

In his personal character the same great qualities were apparent. Unassuming in manner, genial and kindly in his intercourse with his fellow-men, never showing impatience or irritation, devoid of personal ambition of the baser sort or of the slightest desire to exalt himself, he went far toward realizing the ideal of the unselfish, Christian gentleman. In the minds of those who knew him, the greatness of his intellectual achievements will never overshadow the beauty and dignity of his life.

This estimate of his character is corroborated and illustrated by letters found among his papers, many of which

are quoted below. These few letters, along with a much larger number of letters written to him, are preserved by the Van Name family (his niece and nephews) who have kindly permitted me to examine them and to use such as are of immediate interest. A perusal of this correspondence shows that many of the letters had not been preserved by Gibbs; for, though amongst the writers there are a number of conspicuous names, others, equally outstanding (for instance, Clerk Maxwell) who are known to have written to Gibbs, are missing. The few letters written by Gibbs himself—for this was before the time of typewriters and carbon paper for professors—are apparently either first drafts or copies which he had kept for reference.

To Professor J. P. Cooke who had requested him to write, for the *Proceedings* of the American Academy, "an appreciatory notice of the life-work" of Clausius, one of the founders of the science of thermodynamics, Gibbs replied:[1]

New Haven, June 10/89.

Professor J. P. Cooke,
My dear Sir:

The task which you propose is in many respects a pleasant one to me, although I have not much facility at that kind of writing, or indeed, at any kind. Of course, I should not expect to do justice to the subject, but I might do something.

There are some drawbacks: of course it has not escaped your notice that it is a *very* delicate matter to write a notice of the work of Clausius. There are reputations to be respected, from Democritus downward, and susceptibilities which may be hurt, if not of the distinguished men directly concerned, at least of their hotheaded partisans.

Altogether I feel as if I had to take my life in my hands.

Without making a positive engagement at this moment, as soon as I can get a little relief from some pressing duties, I will look the matter up and see what I can do, and will communicate with you further.

Yours truly,

J. W. G.

[1] The notice of Clausius which appeared in Proc. Am. Acad., 16, 458 (1889), is reprinted in the Scientific Papers, Vol. II.

Maxwell was apparently the first to note the significance of Gibbs's work, for in 1875 he wrote in *Nature* (vol. 11, p. 357): "I must not omit to mention a most important American contribution to this part of thermodynamics by Professor Willard Gibbs, who has given us a remarkably simple and thoroughly satisfactory method of representing the relations of the different states of matter by means of a model. By means of this model, problems which had long resisted the efforts of myself and others may be solved at once." Maxwell's insight is shown by the statements, made in 1876, that the methods introduced by Gibbs "are likely to become very important in the theory of chemistry" and "more likely than any others to enable us, without any lengthy calculations, to comprehend the relations between the different physical and chemical states of bodies." He was indeed so much interested that he sent to Gibbs a plaster model, constructed with his own hands, to illustrate the correlated changes in volume, entropy and energy of water-substance. No letters from Maxwell have been preserved, but we find his interest reflected in letters such as the following:

Darroch, Falkirk, 15/Dec/76

Professor W. Gibbs,
Dear Sir:

Some months ago I had a letter from Professor Clerk Maxwell, of Cambridge, in which he called my attention to some expositions of yours on the thermal equilibrium of bodies in different states. Since then I have "moved heaven and earth" in the shape of printers, publishers, booksellers, agents, etc. to get me a copy of your work but unfortunately all without effect. As a last resource I have ventured to come to you, to ask you to send me such information as will enable me to send for a copy of your work, or if it is not trespassing too much on your time to ask you to have the kindness to order a copy to be sent to me.

I have sent you by this post a copy of a paper of mine on a similar subject. From it you will see that the nature of the vessel in which water is boiled has no influence on the boiling point.

[1] See Maxwell, "Theory of Heat" 8th edition (1885) pp. 195–208.

Water may be raised far above its boiling point in vessels made of metal as well as in glass vessels.

Trusting you will forgive this trespass on your kindness,

I have the honour to remain,

Yours truly,

JOHN AITKEN.

The longest correspondence—which however has clearly not been preserved complete—is with Ostwald; it includes the negotiations which eventually resulted in the publication of a German translation, by Ostwald, of the memoir on heterogeneous equilibrium. The first letter is from Ostwald, then in Riga, who wrote, April 26, 1887, announcing his collaboration with van't Hoff in commencing the publication of the *Zeitschrift für physikalische Chemie,* inviting Gibbs to contribute articles and requesting permission to use his name as one of those associated with the publication; and continued as follows:[2]

I take this opportunity of expressing the wish, shared by many colleagues, that your great memoir, which is fundamental to the application of thermodynamics to chemical problems, be made more readily accessible. Could you not bring yourself to republish it in expanded form, illustrated with specific examples, of which there is now no lack? I must admit that your work is very difficult, particularly for the chemist, who is seldom conversant with mathematical reasoning. I would like it best if you would agree to a German edition. I would be glad to arrange for its publication and to take care of the translation. In this way the study of this domain would be greatly intensified, especially in Germany.

To this Gibbs replied, August 3, 1887:

Dr. W. Ostwald,

My dear Sir:

Please accept my apologies for my delay in replying to your very kind letter. Some points required a certain consideration (the more, as at that time I had not yet seen your valuable journal), and when I had laid your letter aside, the pressure of other engagements prevented me from returning to it.

I am very glad that you have undertaken a journal of this character, for which there seems to be an abundant opening. The subject is one in which I have felt a lively interest, and to which, although my time for the last years has been given almost exclusively to other subjects, I have always hoped to be able to return. Nevertheless I am not able to make any engagements, but can only assure you of my good wishes for your undertaking and my grateful appreciation of your kind interest in my own work,

I remain,

Yours very respectfully,

J. WILLARD GIBBS.

The next letter preserved is from Ostwald, dated November 14, 1888, in which he thanks Gibbs for helping him to secure a copy of the memoir and asks:

Would you be willing that I publish a German translation of your fundamental paper? It is so inaccessible, and contains so much that is important, that such an undertaking seems to me to be very useful.

To this Gibbs replied, December 7, 1888:

Professor W. Ostwald,

My dear Sir:

I should be very glad to have my essays in thermodynamics made accessible to a larger circle of readers. Yet I should have feared that the call for a German edition would hardly justify the labor and expense of the translator and publisher. If, however, you think differently, I should be glad to hear from you more definitely in regard to what you would think practicable.

With thanks for your kind interest in my work, I remain,

Yours truly,

J. W. GIBBS.

Ostwald's translation was published in 1892, but without notes or preface by Gibbs and without his portrait, notwithstanding repeated requests for all three. In 1895, however, Ostwald did prevail upon him to send a negative from which was made the heliogravure published as a frontispiece to volume 18 of the *Zeitschrift für physikalische Chemie* in 1895; from this in turn was made the picture reproduced in this article.

To return now to the paper "On the Equilibrium of Heterogeneous Substances." It is prefaced by the motto, from Clausius,

Die Energie der Welt ist constant
Die Entropie der Welt strebt einem Maximum zu.

[2] Original in German.

As illustrations of the condensed style —a style in which every word counts and no word is redundant—I quote the opening paragraph and the concluding page, between which are some 300 pages of close reasoning in which many important theorems are enunciated, and rigorously derived, for the first time.

The comprehension of the laws which govern any material system is greatly facilitated by considering the energy and entropy of the system in the various states of which it is capable. As the difference of the values of the energy for any two states represents the combined amount of work and heat received or yielded by the system when it is brought from one state to the other, and the difference of entropy is the limit of all possible values of the integral $\frac{dQ}{t}$ (dQ denoting the element of the heat received from external sources, and t the temperature of the part of the system receiving it,) the varying values of the energy and entropy characterize in all that is essential the effects producible by the system in passing from one state to another. For by mechanical and thermodynamic contrivances, supposed theoretically perfect, any supply of work and heat may be transformed into any other which does not differ from it either in the amount of work and heat taken together or in the value of the integral $\frac{dQ}{t}$. But it is not only in respect to the external relations of a system that its energy and entropy are of predominant importance. As in the case of simply mechanical systems, (such as are discussed in theoretical mechanics,) which are capable of only one kind of action upon external systems, viz., the performance of mechanical work, the function which expresses the capability of the system for this kind of action also plays the leading part in the theory of equilibrium, the condition of equilibrium being that the variation of this function shall vanish, so in a thermodynamic system, (such as all material systems actually are,) which is capable of two different kinds of action upon external systems, the two functions which express the twofold capabilities of the system afford an almost equally simple criterion of equilibrium.

. . . .

The foregoing examples will be sufficient, it is believed, to show the necessity of regarding other considerations in determining the electromotive force of a galvanic or electrolytic cell than the variation of its energy alone (when its temperature is supposed to remain constant), or corrected only for the work which may be done by external pressures or by gravity. But the relations expressed by (693), (694), and (696) may be put in a briefer form.

If we set, as on page 89, $\psi = \varepsilon - t\eta$ we have, for any constant temperature, $d\psi = d\varepsilon - t d\eta$ and for any perfect electro-chemical apparatus, the temperature of which is maintained constant,

$$V'' - V' = -\frac{d\psi}{de} + \frac{dW_G}{de} + \frac{dW_P}{de} \qquad (679)$$

and for any cell whatever, when the temperature is maintained uniform and constant

$$(V'' - V')\, de \leqq -d\psi + dW_G + dW_P \qquad (698)$$

In a cell of any ordinary dimensions, the work done by gravity, as well as the inequalities of pressure in different parts of the cell may be neglected. If the pressure as well as the temperature is maintained uniform and constant, and we set, as on page 91,

$$\zeta = \varepsilon - t\eta + pv$$

where p denotes the pressure in the cell, and v its total volume (including the products of electrolysis), we have

$$d\zeta = d\varepsilon - t\, d\eta + p\, dv,$$

and for a perfect electro-chemical apparatus,

$$V'' - V' = -\frac{d\zeta}{de} \qquad (699)$$

or for any cell,

$$(V'' - V')\, de \leqq -d\zeta \qquad (700)$$

In the Scientific Papers, Volume 1, this is followed immediately by Gibbs's own abstract, prepared for, and published in *The American Journal of Science*;[1] but a better brief statement for the present purpose is contained in the letter of January 10, 1881, to the American Academy of Arts and Sciences in which Gibbs expresses his appreciation of the award of the Rumford Medal to him by the Academy, and continues:

One of the principal objects of theoretical research in any department of knowledge is to find the point of view from which the subject appears in its greatest simplicity. . . .

The leading idea which I followed in my paper on the Equilibrium of Heterogeneous Substances was to develop the *roles* of energy and entropy in the theory of thermo-dynamic equilibrium. By means of these qualities the general condition of equilibrium is easily expressed, and by applying this to various cases we are led at once to the special conditions which characterize them. We thus obtain the consequences resulting from the

[1] Volume 16, pp. 451–458, 1878.

fundamental principles of thermo-dynamics (which are implied in the definitions of energy and entropy) by a process which seems more simple, and which lends itself more readily to the solution of problems, than the usual method, in which the several parts of a cyclic operation are explicitly and separately considered. Although my results were in a large measure such as had previously been demonstrated by other methods, yet, as I readily obtained those which were to me before unknown, or but vaguely known, I was confirmed in my belief in the suitableness of the method adopted.

A distinguished German physicist has said,—if my memory serves me aright,—that it is the office of theoretical investigation to give the form in which the results of experiment may be expressed. In the present case we are led to certain functions which play the principal part in determining the behavior of matter in respect to chemical equilibrium. The forms of these functions, however, remain to be determined by experiment, and here we meet the greatest difficulties, and find an inexhaustible field of labor. In most cases, probably, we must content ourselves at first with finding out what we can about these functions without expecting to arrive immediately at complete expressions of them. Only in the simplest case, that of gases, have I been able to write the equation expressing such a function for a body of variable composition, and here the equation only holds with a degree of approximation corresponding to the approach of the gas to the state which we call perfect.

Starting from the basis that

For the equilibrium of any isolated system it is necessary and sufficient that in all possible variations of the state of the system which do not alter its energy, the variation of its entropy shall either vanish or be negative,

he proceeds to develop the general relations which determine the attainment of equilibrium in systems of many different kinds, simple and complex, subject to many varieties of restrictive conditions. To convey an idea of the precise nature of Gibbs's achievement is no easy task; and I shall accordingly make free use of what others, better fitted, have written, keeping in mind Stevenson's lines

Of all my verse, like not a single line;
But like my title, for it is not mine.
That little from a better man I stole;
Ah, how much better, had I stol'n the whole!

The Copley medal of the Royal Society was, in 1900, awarded to him as "the first to apply the second law of thermodynamics to the exhaustive discussion of the relation between chemical, electrical and thermal energy and capacity for external work." Larmor in the article "Energetics" in the Encyclopedia Britannica wrote: "His monumental memoir . . . made a clean sweep of the subject; and workers in the modern experimental science of physical chemistry have returned to it again and again, to find their empirical principles forecasted in the light of pure theory, and to derive fresh inspiration for new departures." In announcing Gibbs's death Ostwald wrote merely: "To general chemistry he gave for a hundred years form and content."

In a recent essay entitled "The Influence of J. Willard Gibbs on the Science of Physical Chemistry," Professor F. G. Donnan writes:[1]

It has often happened in the history of science that after or during a period of activity, there has come a man of genius, who, combining profound insight with the highest powers of logical reasoning, has presented the world with a precisely formulated and far-reaching synthesis of scientific principles. We see the first great physical synthesis of this sort in the laws of motion and the theory of universal gravitation as enunciated by Newton in the seventeenth century. The further study of the laws relating to the motion and equilibrium of material bodies culminated in the great and comprehensive formulation due to Lagrange and Hamilton in the eighteenth and early nineteenth centuries.

When we endeavor to trace the history of thermodynamics, we find a similar development; the great step taken by Carnot, the gradual recognition of the general principle of the conservation of energy, the statement of the second law by Clausius and Kelvin, and finally the great, comprehensive, and generalized statement of Willard Gibbs, whose work bears the same relation to the science of thermodynamics that the work of Lagrange and Hamilton bears to the science of mechanics. The wonderful power of profound reasoning and extreme generalization possessed by Gibbs entitles him to an equal rank in an allied branch of science. Clerk Maxwell and Boltzmann, perceiving that in the development of the dynamic theory of gases, the principles of mechanics must be supple-

[1] *J. Franklin Inst.*, *199*, 457–84 (1925).

mented by statistical reasoning, had established the very important science of statistical mechanics. Their investigations applied to a system containing a vast assemblage of molecules in random motion. Gibbs, not content with his generalized analytical and geometrical formulation of thermodynamics as based on the "empirical" principle of entropy, and seeking a rational foundation for this branch of science, turned his attention to statistical mechanics. In characteristic manner, he proceeded to apply dynamical and statistical reasoning not merely to a single assemblage of molecules but to a vast, though unconnected, assemblage or "ensemble" of systems subject to the same dynamical laws and each characterized by a very great number of degrees of freedom. Not only did he obtain the rational foundation of thermodynamics which he sought, but the science of statistical mechanics received an extension and generalization comparable with that given by Lagrange and Hamilton to the science of mechanics.

Writing some fifteen years ago, Henry Adams stated that, after Benjamin Franklin, Gibbs was the greatest man of science America had produced. He might well have added that in the history of the physical science of the seventeenth, eighteenth and nineteenth centuries, Gibbs ranks with men like Newton, Lagrange, and Hamilton, who by the sheer force and power of their minds have produced those generalized statements of scientific law which mark epochs in the advance of exact knowledge.

His memoir was "nothing less than the creation of a complete and perfectly general thermodynamical theory of physico-chemical equilibrium. At the time when Gibbs wrote this paper, very little was known about the physical nature of atoms and molecules, except their relative masses. He saw, however, that a great advance was possible by an extension and generalization of the fundamental principles of thermodynamics, since these can be stated without reference to atomic and molecular magnitudes. As we know from his writings, Gibbs was certainly no disbeliever in, or despiser of, the atomic and molecular concepts. Realizing, however, the meagreness and uncertainty of this knowledge, he determined wisely to build on a sure foundation, and he saw that this foundation was provided by the theory of energy and entropy. The result was the creation of an almost entirely new physico-chemical science, which we may, for want of a better word, call thermodynamic chemistry. This creation by Gibbs of a comprehensive physico-chemical thermodynamics was, and long will be, of enormous importance both for chemistry and physics. However much we may learn about the individual units of the physico-chemical world, we shall always be vitally concerned with certain very important aspects of the average behavior of the "crowd." Perhaps in time statistical mechanics or statistical electro-magnetics will supply all the knowledge we require, but these branches of science have still a long way to travel before that goal is reached. Even in very recent years, the "electron crowd" has come under the sway of thermodynamical methods, as, for example, in the case of thermal ionization and other types of electron emission and absorption.

. . . Van 't Hoff, by his work on the oceanic salt deposits of the Stassfurt district, created the science of experimental mineralogy as a special branch of the theory of heterogeneous equilibria. Nowhere in the world has this science achieved a more splendid development than in the Geophysical Laboratory at Washington. The same theory has revolutionized the study of alloys and much of the science of metallurgy. The glowing iron and steel which pour daily from thousands of furnaces depend for their intelligent understanding and control on the impulse sent forth into the world from the quiet study at Yale University. Has there ever been a greater example of that eternal truth, that from the finest theory is born the finest practice? During the Great War, the safety of Great Britain and her Allies depended at a very critical moment on the ability of an Englishman, Dr. Francis Arthur Freeth (Chief Chemist to the celebrated firm of Messrs. Brunner, Mond and Co.), rapidly to devise well-founded and scientifically controlled processes for the daily manufacture of enormous quantities of ammonium nitrate from mixtures of other salts. Freeth, a devoted and expert disciple of Gibbs, Roozeboom, and Schreinemakers, solved the problem by means of the graphical methods founded on the thermodynamical theory of heterogeneous equilibria. Thus the invisible links of human thought reached across the years from the peaceful study of an American mathematician almost to the very mouths of the guns.

The work and inspiration of Gibbs have thus produced not only a great science, but also an equally great practice. There is, to-day, no great chemical or metallurgical industry which does not depend, for the development and control of a great part of its operations, on an understanding and application of thermodynamic chemistry and the geometrical theory of heterogeneous equilibria.

The very inadequate sketch of Gibbs's work and influence in one field of knowledge, which has been attempted in the foregoing pages, may perhaps suffice to show that he was the founder and creator of the science of physico-chemical thermodynamics. Like Lagrange and Hamilton, he was the great and profound mathematician

(or mathematical physicist) who, utilizing the scientific advances of half a century and applying to them the full power and scope of deductive logic, so extended and generalized the results of his predecessors and contemporaries as to create a new foundation and a new starting point for human effort. At a time when the atomic and molecular theories were still comparatively undeveloped, the work of Gibbs gave to physical and chemical science a fresh impulse of the highest value and the greatest fruitfulness. The mighty wave of this impulse has extended to many allied fields of knowledge, to mineralogy, metallurgy and physiology, and to almost every branch of industrial practice.

As another witness let us take Le Chatelier, who independently had reached particular conclusions already embodied in Gibbs's work, writing (in French) in the Gibbs number of the *"Chemisch Weekblad"*

The work of Gibbs is, from several points of view, of exceptional character. He is the real creator of chemical thermodynamics, having written this new chapter of science at a time when nothing else in this domain existed; and with a single stroke he has brought this knowledge to such a degree of perfection that in fifty years almost nothing has been added. The various men who have considered the same question have only paraphrased his work; they have sometimes supplemented it in detail, but more often they have only applied to particular cases the general laws formulated by Gibbs. He expounded the phase rule in two pages; large volumes have been written to show its manifold applications.

This result is all the more extraordinary in that Gibbs seems to have possessed only slight knowledge of chemistry. He adduces few examples, and those very simple: the solubility of sugar or salt, the dissociation of hydriodic acid; but his discussion of these simple cases may be extended directly to the most varied systems. One wonders sometimes if he really appreciated the range of his formulas and their usefulness to chemists; and is astonished that he should not have troubled to state his results in terms of the measurable quantities which alone interest the chemist.

The great merit of Gibbs is that, starting from the rigorously exact principles of thermodynamics, he investigated all of the consequences which may thence by absolutely rigorous reasoning be deduced. It is a poor method to introduce uncertain hypotheses, as Clausius did, or approximate experimental laws, as van 't Hoff did. It is certainly necessary, in the discussion of actual cases, to make use of approximate laws—such as the ideal gas law, and the Raoult law of dilute solutions—but they should not be used until the train of rigorous reasoning is complete. To introduce them earlier leads to formulas whose degree of approximation is unknown; and this leads to an appearance of uncertainty which in Gibbs's work is entirely absent.

LeChatelier, after describing the steps in his early work on the application of simple thermodynamic methods to the solution of specific chemical problems, continues:

Later, when I became acquainted with Gibbs's original memoir, I found that the laws which I had painfully established were only special cases of his general formula. Neither van 't Hoff nor I had in fact contributed anything new in principle; we had however rendered chemists a service by being the first to bring to their attention laws which no one had recognized in the mathematical formulas of Gibbs.

In the same place, Ostwald writes:

In order to understand Gibbs's work, this most important of all aids towards the development of affinity theory (Verwandschaftslehre), I began to study it after I had succeeded, not without trouble, in obtaining a copy. I found it hard reading, but recognized its unquestionably very great significance. Prior to this time it had been essayed by very few men, amongst whom were Clerk Maxwell and van der Waals, who both had mentioned and used it. To grasp it more thoroughly I found no better means than to translate the paper word for word; it cannot be abstracted, for, being written in such condensed form, no further abbreviation is possible. Moreover it seemed to me that an edition in German would bring to light this long hidden treasure and thus contribute to the progress of science.

This memoir had a very great influence upon my own development. For Gibbs, although he does not mention it expressly deals exclusively with energy factors, free from any kinetic hypotheses whatever. For this reason his conclusions are as certain, as permanently true as any that are humanly obtainable. Indeed, no error, either in his formulas or in his conclusions, or—what is still more difficult of achievement—even in his postulates has yet been discovered. For not a few scientific papers, based on the most rigorous logic and mathematics, are nevertheless worthless because they imply assumptions and conditions which are not valid; but this confusion is altogether absent from the work of Gibbs.

In his preface to the German translation of the thermodynamic papers, Ostwald wrote in 1892—and his last point is just as true now as it was then:

The importance of the thermodynamic papers of Willard Gibbs can best be indicated by the fact that in them is contained, explicitly or implicitly, a large part of the discoveries which have since been made by various investigators in the domain of chemical and physical equilibrium and which have led to so notable a development in this field. . . . The contents of this work are to-day of immediate importance and by no means of merely historical value. For of the almost boundless wealth of results which it contains, or to which it points the way, only a small part has up to the present time been made fruitful. Untouched treasures of the greatest variety and of the greatest importance both to the theoretical and to the experimental investigator still lie within its pages.

Some of those already quoted have adverted by implication, if not directly, to the purely practical consequence of Gibbs's work; but this can be supplemented by direct statements. For instance, Tammann writes in the *Chemisch Weekblad* (Vol. 23, 422 (1926)):

There is undoubtedly no abstract theoretical contribution to science which has exerted such a decisive influence upon the building of a scientific foundation for the basic industries as has that of Gibbs on heterogeneous equilibria. It is doubtful in how far he foresaw the applications of his theorems to practical questions such as the constitution of alloys, roasting and smelting processes, the production of refractories or of fluid slags and their equilibrium with liquid metal. In a general theory there is apparently a power which exceeds that of its creator; it proves to apply to regions extending away beyond the field of view of its originator.

Gibbs's basis was wholly the principles of thermodynamics as developed during his lifetime; but he applied these principles not only to the change of state of single pure substances, as others had done, but also to mixtures of two or more substances. For this purpose he devised other new thermodynamic functions which led him to a series of fundamental theorems, to the phase rule and to theorems as to special points on equilibrium curves, all of which are of lasting significance to experimental chemistry. . . .

We now command not only methods which enable us to describe precisely the mutual behavior of two substances through a wide range of temperature and pressure, and to specify whether the solid phase will consist of a single kind of crystal or of mix-crystals over a range of composition; but we also have, for many of the most important substances, binary and ternary equilibrium diagrams which have become the solid foundation of many technical processes by enabling us to interpret the structure as seen through the microscope, of many materials of construction, such as steels, brasses and bronzes. These diagrams are of many different forms, yet they are all subject to one rule, the phase rule of Gibbs. Thus the abstract theoretical investigations of a studious recluse constitute the scientific basis for the main part of the knowledge of the modern metallurgist.

In the same place there is a short article by Donnan on "The Phase Rule of Gibbs in Industry," in part as follows:

In the carrying out of chemical and metallurgical processes on an industrial scale it happens usually that we have to deal with the interactions and chemical equilibria occurring in a heterogeneous system containing several phases, whether gaseous, liquid or solid. Furthermore, whatever may be the process in question, we are almost invariably faced with the final problem of separating the desired substance or substances in a sufficiently pure form by such familiar processes as liquation, crystallization, solution, distillation, sublimation, absorption, "salting-out," etc., etc., so that in all these fundamental "Unit Operations" of chemical industry we have to deal with the phase-equilibria of heterogeneous systems. These general remarks will suffice to indicate the fundamentally important role which a study of heterogeneous equilibria plays in the whole vast range of chemical and metallurgical processes. A knowledge of how to predict, control and utilize to the best advantage the equilibria occurring in heterogeneous systems is one of the "philosopher's stones" of modern chemical industry, whereby the base metal of empiricism is transformed into the gold of scientific efficiency.

Other statements illustrating the economic importance of this abstruse imaginative investigation could readily be found; but they are unnecessary. Suffice it to say that most of the industrial applications made hitherto are based on the Phase Rule which, stated by Gibbs in a couple of pages, has required for its exposition books containing many hundreds of pages. And yet the phase rule is only

a qualitative statement, its essence being that the number of independent variables upon which the equilibrium state of any given system depends, is decreased by one for every phase present; it tells us the number of variables but does not predict the *magnitude* of the effect produced by changing them. Its derivation was, in a sense, incidental to the task which Gibbs set himself—namely to formulate exact quantitative relations between the various factors influencing the equilibrium. These quantitative relations themselves, and the other theorems of Gibbs, when they are expounded and illustrated as the phase rule has been, and thus become more generally understood, will without doubt also yield results of great practical significance and importance.

In conclusion, may I apply to Gibbs his own very apt words to be found in his notice of Clausius and of his colleague Hubert Anson Newton, the astronomer:

> The constructive power thus exhibited, this ability to bring order out of confusion, this breadth of view which could apprehend one truth without losing sight of another, this nice discrimination to separate truth from error,—these are qualities which place the possessor in the first rank of scientific men. . . . But such work as that of Clausius is not measured by counting titles or pages. His true monument lies not in the shelves of libraries, but in the thoughts of men, and in the history of more than one science.[1]
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> But these papers show more than the type of mind of the author; they give no uncertain testimony concerning the character of the man. In all these papers we see a love of honest work, an aversion to shams, a distrust of rash generalizations and speculations based on uncertain premises. He was never anxious to add one more guess on doubtful matters in the hope of hitting the truth, or what might pass as such for a time, but was always willing to take infinite pains in the most careful test of every theory. To these qualities was joined a modesty which forbade the pushing of his own claims, and desired no reputation except the unsought tribute of competent judges.[2]

Note: The attention of the reader is directed to an interesting article "Josiah Willard Gibbs and his Relation to Modern Science," by F. H. Garrison, in THE SCIENTIFIC MONTHLY, vol. LXXIV, 470–484; 551–561; vol. LXXV, 41–48; 191–203 (1909). There is also a brief article "Josiah Willard Gibbs and the Extension of the Principles of Thermodynamics" by F. W. Stevens in a recent number of *Science* (Vol. 66, 159–63, 1927).

[1] "The Scientific Papers of J. Willard Gibbs," Vol. II, pp. 263, 267.

[2] ibid., p. 282.

THE ATOM AS A SOURCE OF ENERGY

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Atomic physics is generally supposed to deal with theories too abstract to be of practical interest. Yet the recent history of applied science shows that many discoveries in physics which at first seemed to possess only theoretical significance, afterwards proved to be of fundamental importance to the evolution of engineering, and to the evolution of civilization.

For example, Maxwell's ingenious electromagnetic theory of light remained nothing but a theory for fifteen years after its publication in 1873. Thereafter, Hertz, guided by Maxwell's "Treatise," carried out his marvelous experimental work which demonstrated the actual existence of electric waves. Even after this, seven years passed before practical ingenuity created wireless telegraphy based on these Hertzian experiments. Could a student of Maxwell's difficult treatise have foreseen in 1873 what the world would owe to it some day? Could he have pictured that a ship in mid-ocean, alone and in distress, would be able to call for help and to have steamships rushing to its assistance from points hundreds of miles away; or that the lonely rancher in his distant shack might be able to participate, through the medium of a receiving set, in the artistic and intellectual pleasures of the remote metropolis?

The nineteenth century has often been called the century of electricity. Its second half has given us a vast number of important electrotechnical inventions, nearly all of which are based on scientific discoveries made during the first half of the nineteenth century. The first decades of the twentieth century have witnessed a new advance in physics which has been more rapid and more revolutionary than any in the whole history of science. In this short space of time, a new branch of physics has arisen which deals with the structure of the atom, and this field has already become a department of science full of the most marvelous revelations.

No physicist, however, is able to predict to-day that the remainder of the twentieth century will see the technical exploitation of the theoretical discoveries of our age. Were humanity to succeed in harnessing the enormous forces of nature dormant within the atoms, this achievement would inevitably mark a revolution of civilization undreamt of in the wildest speculations.

Indications of the tremendous internal energy of the atom to which I have just referred became evident to physicists through a remarkable and, for a time, quite inexplicable phenomenon which was observed soon after the discovery of radium—that is, during the last years of the past century. It became apparent that every preparation of radium unceasingly produces an immense amount of heat. For example, a preparation containing one kilogram of radium would be capable of raising the temperature of one liter of water from its freezing point to its boiling point within forty-five minutes, and could repeat this process for an apparently infinite number of times.

When this vast and seemingly inexhaustible heat-producing power of radium was discovered, physicists at first

confessed themselves completely baffled, for they could not imagine where this enormous amount of energy could possibly come from. Some conjectured that it was due to an unknown form of energy diffused in the air which was, so to say, stored up in the radium and again given off by it. Others found it necessary to go even further and began to doubt a fundamental law of physics which states that energy can never arise spontaneously.

In spite of the many theories brought forward to account for the strange phenomenon, the riddle of radium remained unsolved until the first years of the twentieth century, when a new scientific truth began to gain ground. Up to that time physicists and chemists considered atoms to be indivisible and, above all, immutable. Then they began to recognize quite clearly that atoms are themselves composed of smaller, electrically-charged particles, and that under certain conditions such particles might be split off from the atom and in this way might alter its chemical characteristics.

Let us see how this conception of atomic structure serves to explain the mysterious heat-production by radium. It has been known for a long time that electrically-charged bodies act upon one another. The force so exerted is one of attraction if the one body is charged positively and the other negatively, and one of repulsion if both bodies are charged positively or both negatively. These electrical forces increase as the distance through which they act decreases. [In fact, the force increases in the inverse ratio to the square of distance, so that its strength is increased one hundredfold if the distance between the bodies is reduced to one tenth.] Therefore, it becomes clear that within the submicroscopic sphere of the atom comparatively enormous forces are in operation between the particles, and consequently, we must attribute to the atom a very great internal energy. Part of this energy can be liberated and thus become observable either if a change takes place in the internal grouping of these small particles, or if such particles are split off.

On the basis that such sub-atomic processes take place within radium atoms, the unceasing spontaneous production of heat is not difficult to explain. All we have to assume is that a certain percentage of the atoms of a preparation of radium undergo disintegration concomitant with the loss of an atomic particle.

This assumption is more than a mere working hypothesis. It has been verified by observation and experiment. Not only has the gradual transmutation of radium into another chemical element been proved beyond doubt, but it has also been possible to detect swarms of minute, electrically-charged particles which are continuously emitted with enormous velocity by every preparation of radium.

Although the idea of the divisibility and transmutability of atoms clears up the mystery of the heat-production of radium, this phenomenon could not be fully accounted for until much more was known about the interior structure of the atom. Since 1911, physicists have known that every atom has a nucleus charged with positive electricity, its volume being only an infinitesimal part of the volume of the whole atom. They know, further, that, revolving round this nucleus like planets round the sun, there are negative primordial particles, so-called electrons. These planetary electrons (as I shall call them for short) all carry the same charge and possess the same mass; it is their number which determines the chemical character of the atom. In the atom of hydrogen only one such planet revolves round its nucleus. There are three in an atom of lithium, 29 in one of copper, 82 in one of lead

and 92 in one of uranium, the heaviest of all atoms known at present. The mass of a single electron is insignificant in comparison with the mass of the whole atom. A single electron constitutes only one 1847th part of the mass of the lightest of all atoms, the hydrogen atom. Thus, practically, the whole mass of atoms is formed by their nuclei.

Nuclei of atoms are themselves composed of electrons and hydrogen-nuclei, but not directly, for we find that electrons and hydrogen-nuclei form their own small aggregates, which in turn build up the nuclei of atoms. Among these aggregates, the so-called alpha-particles are especially important; each of these alpha-particles consists of four hydrogen-nuclei and two electrons. Thus they form groups of four positive and two negative primordial particles. These alpha-particles are identical with the atomic nuclei of the second lightest element, helium, which lately became fairly well known to the general public because of its use in inflating airships.

The linear dimensions of the nuclei are much smaller than those of whole atoms. Hence it follows that the internal energy of a nucleus is many times as great as that of the planetary system surrounding the nucleus. According to the law already mentioned, the electrical forces acting within the nucleus must be about a million times as great as those which act between the nucleus and the planetary electrons.

The great heat production of radium is due to processes which take place within the nuclei of atoms of radium. In consequence of the disintegration of nuclei, particles split off from them and leave with immense velocity. If these particles are stopped by any substance enveloping the radium, they lose their mechanical energy, which then becomes transformed into heat. The heat production of radium is chiefly caused by alpha-particles ejected from disintegrating nuclei.

These alpha-particles leave the radium-atom with a velocity of about 15,000 to 20,000 kilometers per second. The kinetic energy of an alpha-particle, the mass of which is more than 7,500 times the mass of an electron, is therefore comparatively tremendous. To gain an idea of this energy, picture a swarm of as many alpha-particles as go to build up one milligram of helium, and imagine this swarm flying with the velocity of 15 to 20 thousand kilometers per second. The kinetic energy of such a swarm, whose total weight is only a single milligram, would be several hundred times as great as the kinetic energy of an express train traveling at high speed.

In the space of two or three days any given quantity of radium produces as much heat as the same weight of coal produces during combustion. But there is a great difference between the two materials. The coal becomes ashes after giving off its heat. The preparation of radium seems able to go on producing the same amount of heat forever. Thus we are tempted to regard radium as an inexhaustible source of energy.

More thorough investigation, of course, shows that the inexhaustibility is only apparent. The truth is that, in consequence of the perpetual disintegration of atoms, the quantity of radium present will gradually become less. After twenty years the loss in substance will be about one per cent. This loss is so small that from any practical point of view, radium can be considered as nearly inexhaustible. The total amount of heat which one gram of radium can produce before its complete disintegration has been found to be about half a million times as great as the amount of heat that the same weight of coal generates during combustion. In other words, one could extract from one gram of radium the same quantity of heat as could be obtained from the combustion of half a ton of coal.

The example of the disintegration of radium shows us what enormous energy changes originate in such transmutations of chemical elements. The energy changes exceed those observed in the case of ordinary chemical processes about a million fold (if we consider the same mass of substance involved). An evolution of energy about fifty times greater than that which is caused by the disintegration of radium is to be expected as the result of a possible synthesis of helium from hydrogen.

From a theoretical point of view, such synthesis can be, of course, quite easily understood. It will be remembered that the nucleus of an atom of helium is identical with one alpha-particle and consists of four hydrogen-nuclei and two electrons. If such an alpha-particle forms a nucleus of a helium-atom, it is surrounded by two planetary electrons. The complete helium-atom, therefore, contains altogether four hydrogen-nuclei and four electrons. As each single hydrogen-atom consists of one hydrogen-nucleus and one electron, a formation of a helium-atom from four hydrogen-atoms appears to be possible. It is to be expected that such a transformation will be accompanied by a change of energy, because electrical forces act between the hydrogen-nuclei and the electrons taking part in the synthesis, so that with each alteration in their grouping energy must become liberated or consumed.

Physicists have been able to calculate exactly the amount of energy associated with a synthesis of helium. Their calculations were prompted by the fact that the atomic weight of helium is not exactly four times the atomic weight of hydrogen, as might be expected, but is a little smaller. From this fact physicists inferred that energy is liberated during a synthesis of helium. The difference between the atomic weight of helium and four times the atomic weight of hydrogen is, roughly, eight tenths of one per cent. On this basis the amount of energy liberated through a helium synthesis is enormous. The synthesis of a single gram of helium from one gram of hydrogen would produce as much heat as the combustion of twenty tons of coal. The artificial synthesis of a few milligrams of helium in a laboratory would therefore be sufficient to increase the temperature of the room quite noticeably. Thus the internal energy of the nuclei exceeds the chemical energy of the same quantity of substance from one hundred thousand to many million times.

To realize the proportion between chemical and nuclear energy, consider one gram of some kind of matter to undergo chemical changes, like combustion; there will be liberated a few, but never more than perhaps ten liter-calories from this gram, the liter-calorie being the quantity of heat necessary to raise the temperature of one liter of water by one degree Centigrade. On the other hand, through the disintegration of one gram of radium, that is through the exploitation of nuclear energy, 3,700,000 liter-calories would become liberated, and by means of the synthesis of one gram of helium from one gram of hydrogen even 160 million liter-calories might be gained. By contrast with the few calories obtained by the usual chemical changes, the range of possibilities extends to far more than one hundred million in the case of the synthesis of helium.

Perhaps we may ask whether there is any upper limit to the amount of energy that might be extracted from one gram of matter. Modern physics has led us to recognize that there is such a limit, and has also enabled us to state it exactly. Einstein's theory of relativity answers our query. Every substance that gives off energy suffers a loss in mass, which loss, according to the theory of relativity, can be calculated by divid-

ing the amount of energy given off by the square of the velocity of light. It is necessary in this calculation to use so-called absolute units for all measurements; that is, the mass must be expressed in grams, the velocity of light in centimeters per second and the energy in ergs (a hundred million ergs will do the work which is spent in lifting one kilogram to the height of one meter). The meaning of all this is that the mass of a body which gives off energy of the amount of one liter-calorie is being diminished by one twenty millionth of a milligram.

To visualize how nearly imperceptible such a reduction in mass is, imagine a swimming-pool 50 meters long, 20 meters wide and 2 meters deep, which holds 2 million liters of water. Suppose the temperature of this bulk of water to be lowered by 10 degrees Centigrade. On account of this loss of energy the reduction of mass, which loss has nothing at all to do with evaporation or loss by any other cause, would be just one milligram.

The changes of mass associated with energy changes revealed by laboratory experiments are naturally much too small ever to be measurable. Yet, in the case of astronomical processes, such changes of mass reach very considerable amounts. The sun, for instance, radiates every second enough heat to raise the temperature of one billion billion tons of water (that is, of 10^{18} tons) from its freezing point to its boiling point. This enormous and perpetual expenditure of energy causes a corresponding diminution of mass. We find, by means of a simple calculation, that the sun loses through heat-radiation a mass of 4 million tons per second. This would form a bulk so great that it would require several hundred trains to move it. It is quite interesting to compare the perpetual loss in mass of the sun with its total mass. We find that in ten million years the sun loses something like one millionth part of its mass.

It was stated above that a body in emitting one liter-calorie of energy loses one twenty millionth part of a milligram of its mass. Conversely, a body will lose one milligram of its mass when it gives off twenty million liter-calories. Therefore, twenty thousand million liter-calories must be the upper limit to the amount of energy which, in the most favorable case, could be extracted from one gram of matter.

This is, indeed, an inconceivably great amount of energy. The quantity of energy which is hidden in the mass of a single gram would be more than enough to lift a weight as heavy as all the buildings in New York City put together to the height of the highest skyscraper. Or, to give another example, this amount of energy would also suffice to raise the temperature of all the rooms of all the houses of New York City by several degrees. If we possessed some means by which we could extract from matter its total energy, then, instead of thousands of tons of coal or oil, one gram of matter would be enough to propel the biggest of all ocean-going liners across the Atlantic.

Compared with the maximum energy, the energy which can be tapped through the agency of chemical processes appears insignificant. What are the several calories which we get by means of coal compared with the twenty thousand million calories dormant in each gram of every substance! Even the energy which is liberated by the complete disintegration of radium is one five thousandths of that maximum energy; and further, the energy freed by the synthesis of helium is less than one per cent., to be exact, it is eight tenths of one per cent. of that maximum energy.

Now, the disintegration of radium is a process which has been thoroughly studied and minutely observed by means of all kinds of experiments, and it may be asked, is the so-called transformation of matter into energy, through its complete

or almost complete dissolution, a physical process, actually taking place, or does it exist only as a vague supposition in the mind of the theorist? For a year or two, physicists have had good reason to assume that such a process actually occurs, and even to assert that it represents the primordial phenomenon in the universe. This enormously important conclusion was arrived at as the result of investigations of the mass of fixed stars. These determinations led astronomers to infer that all stars, during their life-time, lose by far the greater part of their mass.

The life-time of a fixed star is estimated at approximately one million million (or 10^{12}) years, a period so long that the whole duration of the world's history from the days of the ancient Egyptians down to our own time amounts not even to one per cent. of the millionth part of the life-history of our solar system. Astronomy discerns amongst the stars infants and adolescents, adults in the prime of life and ancients; our own sun belongs to this latter group. By comparing the properties of stars belonging to different stages of life, astronomers have been able to trace, to some extent, the life-story of a fixed star. They have recently found out that during its life-time each star gradually loses the greater part of its mass and that this loss can probably only be explained by the assumption that more radical changes are in progress than mere transmutations of chemical elements.

In the interior of the fixed stars we can be sure of temperatures of many millions of degrees. These enormous interior temperatures apparently result in the annihilation of matter as such. Matter, of course, vanishes only when transmuted. In reality, it leaves the star in the form of radiant energy, and in such a way that for each gram of star-mass that vanishes an amount of heat of twenty thousand million liter-calories is produced.

The assumption of a progressive dissolution of matter offers the only satisfactory explanation of a riddle which has puzzled both astronomers and physicists for more than a hundred years. It is the question of the source of the sun's heat. All explanations which attempted to attribute the enormous and permanent radiation of the heat of the sun to chemical or radio-active processes were found to be inadequate. If the sun were made of anthracite, its combustion could only supply a quantity of heat equal to that which is actually radiated in 2,000 years. If we assume that the sun contains radium, its current expenditure of energy could be explained if each kilogram of its mass contained one and a half milligrams of radium. But owing to the permanent disintegration of radium, the heat-radiation of the sun would fall off by one half within something like 1,500 years. This, of course, would not be concordant with the known facts.

If we substitute for radium a radioactive substance of greater longevity, for instance uranium, then the heat-radiation would only be diminished by half after 5,000 million years. But even if the whole sun were made of pure uranium, only about one half the energy permanently emitted could be produced by the disintegration of this element. Besides, the 5,000 million years during which the heat-radiation of the sun thus diminishes by 50 per cent. would be a very small period compared with the life-time of the sun which astronomers assume to be about one million million years. In whichever way physicists and astronomers tried to solve the riddle of the sun's heat, they were unable to find a satisfactory solution. It was only solved by the latest development of physics through the supposition of a gradual annihilation of matter.

So far, I have dealt with the production of energy by matter. But the question inevitably arises as to whether the reverse primordial phenomenon, the generation of matter out of radiation, might possibly also take place in the universe. If this second primordial phenomenon were lacking as the counterpart of the first, then the universe as such would be bound gradually to waste away, and that within a space not longer than perhaps 10^{15} years. We must therefore ask ourselves what becomes of the vast energy which is unceasingly radiated by all stellar bodies into cosmic space. Could this radiation be reconstituted into matter? I will say just a few words about this problem, which was discussed in a paper of mine which was published in the Proceedings of the Vienna Academy of Sciences some months ago.

The idea of a reconstruction of matter from radiation is connected with difficulties arising from the modern conception which attributes an atomic structure also to radiation. The atoms of radiation are called "light-quanta" in modern physics, and the energy of such a light-quantum is found to be proportional to its frequency.

On the basis of this conception, it becomes evident that ordinary radiation could not immediately be transformed into matter. The rays would have to become, as it were, "mature" for this purpose, beforehand. The transmutation into matter would only be possible for rays of a very high frequency. This frequency ought, at least, to be so high that one light-quantum of the rays would possess the same amount of energy as would be liberated by the annihilation of a single hydrogen-atom.

The light-quanta have, as I said, to be made mature for their transmutation into matter. A possible procedure now seems to result from a remarkable phenomenon which was discovered some years ago by Professor Arthur H. Compton, of the University of Chicago. This phenomenon, now generally known as the Compton Effect, consists in the fact that light-quanta experience an observable diminution in their frequency through collisions with particles of matter, especially with electrons. If atoms or nuclei colliding with light-quanta were in enormously rapid motion, then, however, the frequency could also be raised in a considerable degree. Collisions with rapidly moving material particles thus might impart to a light-quantum that critical frequency which qualifies it for a transmutation into a hydrogen-atom.

To this end, it may perhaps only be necessary for a light-quantum to enter a swarm of corpuscles moving with a velocity equal to that with which atomic fragments are expelled in the process of disintegration of radium. If at any time or place there were a kind of gas in the universe whose particles were darting about with such velocities, then this gas might perhaps help to bring about the transmutation of radiation into matter.

I have endeavored to show the rôle of the atom as a source of energy and I have touched on the question of whether, *vice versa,* energy might become a source of atoms. If both these primordial phenomena be realities, the universe would appear to be passing through a cyclical process. Matter would be dissolved in the stars and would turn into radiation, which would again be transmuted into matter and thus, perhaps, give birth to new celestial bodies.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES[1]

By Professor A. E. KENNELLY
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We all know how simple is our system of money based on dollars and cents. We realize that its simplicity depends upon the ten-to-one or decimal relation of its parts. There are ten mills to a cent, ten cents to a dime and ten dimes to a dollar. All sums of money are thus expressed in dollars with decimal steps.

Unlike our money, our system of weights and measures is complicated and difficult. The ten tables taught in our schools comprise about fifty different units, not decimally connected. Very few people can say these tables from memory, without a mistake. The tables taught in English schools comprise about sixty units. Most of the corresponding American and English units are the same; yet there are fourteen that have different meanings. These are the hundredweight and ton, which are long in England, but usually short with us, the pint, quart, peck and bushel in dry measure, the minim, dram and ounce of apothecaries' measure, likewise the gill, pint, quart, gallon and barrel in liquid measure, all of which last are respectively about 20 per cent. larger in Canada and the British Empire than in the United States. We still keep the old wine gallon of Queen Anne; while the British changed, about one hundred years ago, to the imperial gallon. All these fourteen units are ambiguous, and they frequently lead to misunderstandings.

In order to clear up similar complications, the French introduced, about the year 1800, a new system, which they called the metric system, because it was based on a certain new standard yard, called the meter. The meter is only roughly a yard. It is about 10 per cent. longer than our yard. They applied the ten-to-one or decimal steps to this meter, just as in our decimal money system. The metric system came into general use in France about ninety years ago. It was found to be definite and easy. They called one thousand meters a kilometer, from the Greek word for a thousand, and this serves for the measure of great lengths. A kilometer is thus one thousand world yards, or very closely eleven hundred of our yards. One may travel all over continental Europe, by either highway or railroad and find the distances marked off in kilometers. During the great war, two millions of our young men visited France, and so came into contact with the use of the metric system. Since their return to the United States, there has been a distinct increase of popular interest in the metric system. About twenty-five years ago the advocates of this system were mainly scientists; but since the war, mainly business men. There are only three main units in the metric system—the meter, the gram and the liter. The rest are optional names for decimal steps. Thus the distance from Boston to New York, by the New Haven railroad, is 369 kilometers; but that is only another way of saying 369 thousand meters.

The great advantages of the metric system are its widespread international use, its simplicity and its uniformity all over the world. We know that there are two kinds of tons, three kinds of quarts and many bushels; but there is only one meter. This is because there

[1] Given to the air from Station WEEI, Boston.

is only one meter standard, which is preserved in an underground vault in the International Bureau of Weights and Measures at Sèvres, near Paris, France. In 1872, France donated a small old royal palace and twenty-five thousand square meters of land to the International Bureau for this purpose. The old palace at Sèvres stands within the old royal park of St. Cloud. Princess Mathilde once lived there. It is not far from the famous Sèvres porcelain factory, and it has been relinquished by France to international jurisdiction. Presumably, it pays no taxes, and a French policeman could make no arrest there. Facing the old palace, or pavilion, a new laboratory building was erected in 1875, with double walls, to keep the internal atmosphere nearly uniform all the year round. In this laboratory, copies of the international meter bar are made and compared. Each bar is of special platinum alloy, which preserves an untarnished silvery surface. A standard bar has two scratches cut across its face with a diamond, one at each end. The distance along the bar, between these scratches, is set for one meter, when the bar is kept at the temperature of melting ice. Various working copies of the standard meter are kept in the laboratory; but the standard itself is deposited in the vault, eight meters deep below ground. The vault is opened once every six years, in the presence of witnesses, to demonstrate that the standard meter and standard kilogram are in safe preservation. Twenty-eight countries jointly maintain this international bureau. Four special keys are successively needed to open the vault, and three of them are in the custody of foreign delegates to the International Committee; so that the vault can only be opened when the committee meets at six-year intervals. During the great war, one of these keys was in Germany. If it had been necessary to open the vault during the war, it could only have been done by breaking in. Platinum alloy copies of the meter have been distributed among the nations of the civilized world. They are believed to have been correctly compared with the standard at Sèvres, to a precision of at least one part in five millions. There are two of these certified standard meters in the United States, and all our accurate measures of length in industry and in surveying are ultimately connected with these standards. Such standard bars are treated with the greatest care, lest they should be injured by a jolt or fall. Occasionally such national copies of the international meter are returned to Sèvres, for recomparison and check. In all these cases they are taken by a special messenger. It is no wonder, therefore, that the meter has the same length in all parts of the world.

All the civilized countries of the globe have successively either adopted the metric system in their everyday life or they have taken steps officially to do so in the near future, the English-speaking countries only excepted. But although the English-speaking countries have not yet taken any official action towards the general adoption of the system, yet an impartial inquiry into the history of the last thirty years will probably show that we are actually already in process of gradual transition to the metric system, though how many years it will take to make the transition complete no one can say without the gift of prophecy. Substantially all the precise American scientific work is now carried on in the metric system. A few departments of the U. S. government use the system every day; namely, the Coast and Geodetic Survey, a part of the U. S. Customs and the medical departments of the Army and Navy. There is at least one American industry that uses the system exclusively; *i.e.*, the business of making lenses for eye-glasses and spectacles. All such lenses are prescribed and constructed in the metric

system. Many thousands of monthly bills to consumers of electricity for electric light and power, are made out in terms of the kilowatt-hour, a unit based on the metric system. All our radio wave-lengths are measured and specified in meters. A few American manufacturing firms have voluntarily changed over to the metric system in their factories, for the sake of convenience and simplicity. Their testimony has been that while there was a certain inconvenience and bother in making over lists, schedules, drawings and stock-sheets for a little while after the change, the cost was trivial, and no machinery had to be discarded. Our coinage is associated with the system; because a new nickel, or five-cent piece, weighs just five grams, and our silver coins, from the half-dollar down, weigh at the rate of twenty-five grams to the dollar.

Out of the twenty-five large countries and more than fifty little ones that have already given up their original systems and adopted the metric system, none has ever revoked its decision.

A large element of the steadily increasing trend towards the metric system in our country doubtless comes from the fact that modern communication has greatly increased the interchange of methods and ideas between the nations through the telegraph, the telephone and radio.

The invisible radio waves spread from a transmitting station, in all directions, with the enormous speed of light. The radio waves now carrying my voice far and wide are believed to spread over the globe and to reach the furthest opposite point, or antipodes, near Perth in Western Australia, in about one fourteenth of a second of time. The waves from WEEI in Boston have not yet been picked up in Australia, so far as I know; but I am informed, through the courtesy of the officers of WEEI, that the friendly voice has been caught and identified by radio receivers in various remote places as far west as the Pacific coast and as far east in Europe as England, Belgium and Sweden. In the case of more powerful radio-telegraph stations, signals are regularly received at or near their antipodes, just twenty thousand kilometers away, over the seas. This means that in relation to communication of ideas by radio, the most remote countries are only about one tenth of a second apart. We all live on a tenth-of-a-second radio world. It does not seem likely that such a world can indefinitely support more than one system of weights and measures. It must only be a question of time, on a tenth-second world, when only one system will supervene. Will this surviving system be the sixty-unit English system, the fifty unit American system, or the three-unit metric system?

DIET AND DISEASE

By T. SWANN HARDING

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ONE of the easiest and surest ways to make a comfortable living, if you are sufficiently calloused to disregard the sufferings of your dupes and can practice an ample economy of veracity, is to start some system of "eating for health." The way is easy. You can sell an American almost anything if you insist that it will be good for him, and diet systems are exceedingly seductive to laymen. You will require no knowledge of nutrition and no scientific training. In fact these would be decidedly detrimental. They would "cramp your style" and compel you to speak less freely and definitely. What you will need is a dress suit, a hotel rose room, an intimate manner, an alliterative slogan and an eye to the main chance. Then depend on the ladies to find you out, gush and remunerate you munificently for gulling them!

If really good investigators can often become so perverted as to assure us that incorrect eating causes every pathological condition from dandruff to cancer, in spite of the fact that scientific medicine does not yet understand the etiology of either one, we can not, of course, expect too much of these lay prophets of corrective eating. It is a great misfortune, however, that we so sorely lack in these days men who can write popularly and clearly on scientific subjects without sacrificing dignity and exactitude. It is most unfortunate that no writer apparently exists to combat effectually the stream of utterly asinine verbal garbage continually spurting from press and lecture platform on the subject of human nutrition. But would the average editor publish the work of such a writer anyway?

These sciolistic spell-binders would lead you to believe that correct eating will cure any pathological condition at all. Here, as in all cases where exact scientific fact remains incompletely apprehended, systems differ, often diametrically—just as systems of soul salvation necessarily differ. This is because those who propagate systems err by summarizing from too few particulars, by coloring all facts with their doctrinal idiosyncrasies and by speaking inexactly. That is our custom in ordinary life of course. We ascertain a certain few particulars, we generalize forthwith and before we investigate further, we complete our dogma and thereafter absolutely mutilate an inimical fact before we will so much as give it attention. Thus we achieve "universal" truth for all men!

In science such procedure is grossly pernicious. Yet this is the technique of the diet faddist. Let a man recover from influenza soon after he eats a raw onion and he is almost as certain to attribute the prevalence of influenza to an abstinence from raw onions as is a savage to attribute his good luck on a hunt to the jawbone of an ass he found *en route*. Whereas the one will ever thereafter preach asinine jaw-bones as happy hunting omens, the other will prescribe raw onions for anything remotely resembling influenza. There is little to choose here.

But in spite of the sciolists' cacophonous assertions of complete truth and their actual demonstrations of their profound ignorance, a few facts are gradually coming to light which tend to relate faulty diets and certain pathological conditions as cause and effect. A brief and perhaps shamefully inadequate re-

view of this subject is all that is intended here.

Some ideas are surprisingly old. Marco Polo besides coming upon matrimonial and sexual customs in his travels which would make a modern companionate marriage seem morally reactionary, also found certain Asiatics suffering from neck swellings. He attributed these to the water they drank!

In 1600–1700 Florentine pharmacists were selling lemon water ice as an antiscorbutic. In that century any first class Florentine pharmacy was ready to dispense lemonade upon prescription to ward off scurvy.

Ancient Arabian physicians were advanced in many ways. Centuries ago they had elaborately beautiful hospitals in which nervous patients were soothed with sweet music. Each departing patient was presented with a considerable sum of gold in order that he might convalesce without undertaking hard labor at once. Fancy a hospital giving a departing patient money to-day! How we have progressed!

A faint adumbration of modern glandular therapy appears in the fact that the Arab doctors administered dried fox lung to remedy asthma because the fox can run far without fatigue; they also prescribed fox brain for epilepsy on the theory that mental cunning and proficiency could thus be transmitted to remedy the fits. And these procedures were actually just about as sensible as perhaps two thirds of our present day glandular therapy, utilizing, as it so often does, perfectly impotent substances lacking known active principles.

But the Arabs also administered red bone marrow to cure anemia and modern American physicians did not overhaul them in this until about 1890. Finally the Arab physicians constantly emphasized the importance of diet as related to disease prevention. The great Galen also wrote several books on diet and outlined variations therein suited to the age of the patient, his state of health and the time of the year. Hippocrates went so far as to suggest that all diseases originated in the stomach. Modern physicians tend, if anything, to err in the opposite direction and to give nutrition a place altogether too subordinate in etiology. While the blatant cocksureness of the quack lecturer and newspaper prevaricator on diet should not be emulated the physician is somewhat inclined to ignore the definite advances that science has made here.

Quite naturally no exhaustive treatment can be undertaken in a brief paper by a casual student. But some attempt should be made to call attention to the work of certain usually reliable investigators who have shown that faulty diet demonstrably affects physical tone, immunity to infectious, exhaustion, respiratory and gastro-intestinal maladies in addition to its well recognized rôle as an etiological factor in the deficiency diseases. Many leading physicians could be quoted in support of the statement that physicians as a whole are not what they should be when it comes to nutrition in health and in disease. We may, then, venture to proceed.

What shall we attack first among specific conditions attributable to faulty diet? Since such an enormous majority of infants are rachitic or else suffer from a deficiency of iron, this sector seems momentarily seductive. Ed. Mellanby has worked extensively on experimental rickets.[1] He used the following basic diet—lean meat, bread or cereal, yeast, orange juice and olive oil. This diet is deficient in the fat soluble vitamins, bone-calcification is imperfect and rickets follows. But add vitamins—in cod liver oil, egg yolk, whole milk or beef suet and recovery takes place. Cod liver oil will, according to Mellanby, stimulate recovery even if the diet remain low in calcium, although rickets is a calcium deficiency disease; but the other correctives must have calcium fed

[1] *British Medical Journal*, May 24, 1924, 895; Special Report Medical Research Council of Great Britain, No. 93, 1925.

with them in order to be effective. Incidentally the separation of butter and milk very effectually spoils them both for antirachitic purposes.

The more food a young animal eats the faster it grows. A race is at once on between the growth of pre-bone and its calcification into real bone. Cereals seem actually to prevent calcification, oatmeal offending worst of all, white flour and rice not quite so badly. A mixed diet deficient already in the antirachitic vitamin but containing a great deal of oatmeal porridge will rapidly produce bad rickets, the intensity of the disease depending directly upon the amount of oatmeal eaten. Wheat germ is also bad if eaten alone but is so small in amount in whole wheat bread that it can do little harm. Cereals containing large amounts of calcium and phosphorus often deter bone-building most and seem to contain an actual substance preventive of calcification, a substance that cod liver oil alone can completely antagonize. As the muscles become flabby in rickets, weakened bones may be nature's compensation to adjust to poor musculature. So much for Mellanby.

Other investigators do not altogether agree. This is so in very many cases. It argues no deception, no carelessness. It means simply that in such investigation research workers even yet have to do with many unknown factors and with many which it is highly difficult to keep constant. But this mere fact fatally indicts the exponent of perfect diet systems.

Thus, in so far as oatmeal is concerned, certain American workers have recently failed to confirm Mellanby's results and contend that oatmeal does not contain any agent which actively inhibits bone calcification; at least they can find no evidence for this when they attempt to duplicate his experiments exactly. Other workers, as we shall see, doubt that cod liver oil alone, and without additional calcium, can complete a low calcium diet. Finally there is much interesting matter in the work of Cowgill[2] on cereals as a basic diet very easily and simply supplemented to make an ample diet without the use of milk.

Cowgill and coworkers used whole grain cereals, oats, wheat and corn, to comprise from 65 to 80 per cent. of the diet of standard white rats. The only other foods fed were cooked whole egg, cane molasses and lettuce, but the rats retained perfect health. This seems to demonstrate that any whole grain cereal may easily be supplemented with such ordinary common foods to make a complete diet without milk being required at all. With 65 per cent. cereal in the diet, growth, reproduction and lactation all took place normally; with even 80 per cent. the growth of young rats took place unimpeded, though lactation was impaired, but that is a grossly abnormal diet. What is true of young rats is generally true of young humans and any diet which satisfies youth is sufficiently complete for adults, as a rule. Hence it appears that since such food was fed rats "over lengthy periods corresponding roughly to at least the first ten years of man's life span, one is led to suspect that the possibilities in the way of successful nutrition by man on high cereal diets supplemented by relatively few but carefully selected foods other than milk are greater than have been appreciated before." This certainly should sustain those who can not tolerate milk or find it difficult to secure.

Deficient foods also cause bad teeth.[3] While foods containing the fat soluble vitamins—milk, egg yolk, butter, animal and fish fat, cod liver oil—conduce to the formation of good teeth, cereals, especially oatmeal, seem to induce defective teeth, particularly in the absence of vitamins. Certain children were fed the following three test diets:

[2] *Journal* of the American Medical Association, 89, 1770, and 1930, 1927.

[3] *The British Medical Journal*, March 20, 1926, 515.

A—Much milk, some cod liver oil, little cereal (no oatmeal) and other foods to balance.
B—Little milk, much cereal, including oatmeal, and other foods to balance.
C—A diet intermediate between A and B.

The new points of dental decay developed per child while fed these diets were respectively as follows: On diet A, 1.4; C, 2.9, and B, 5.1. This indicates the great deficiency of diet B and the relative excellence of diet A.

Bad diets produce evil effects as visitations upon future generations. Bitches fed defective or rachitic diets produced pups so predisposed to rickets that even a period of good food did not remove the young from the danger of developing rachitic lesions. These diet defects also increased the susceptibility of the young to respiratory diseases like pneumonia and catarrhal conditions, which latter often extend to and impair the alimentary tract. Such deficiencies are really very common in human nutrition and may be responsible for much infant mortality since, in such cases, the proper feeding of the child after it is born is not enough; the pregnant mother must have been properly fed as well.

McCollum has rightly called attention to the insidious effects of a slightly deficient diet over a long period; he has suggested that it lowers vitality, shortens life and advances senility. Dr. Hsien Wu, in an extremely suggestive lecture, "Chinese Diet in the Light of Modern Knowledge of Nutrition,"[4] applied this theory to his own race in particular. The Chinese depend very largely upon vegetable proteins. Their meat consumption *per capita* per day is very low. Vegetable proteins are demonstrably less digestible and less efficient biologically than are animal proteins.

Thus from the standpoint of biological utility wheat protein may be rated 40 per cent., corn meal protein 30 per cent. and pea protein 56 per cent., while milk and ox-meat proteins are 100–104 per cent. The coefficient of digestibility of animal foods is about 97 per cent., of cereals about 85 per cent. and of legumes about 78 per cent.; when legumes and cereals are fed together their coefficient falls below that of either fed alone. The Chinese eat about one seventh as much meat as Americans. Milk is scarce in China and often viewed askance when available. It, therefore, appears that the Chinese have been consistently under-nourished since ancient days when they ate vastly more meat, lived longer and stood taller. To-day the Chinese is peaceful, sequacious, unprogressive, unenterprising, non-persevering; his stature is poor, his physique bad, his mortality high. Dr. Wu is willing to believe that long continued malnutrition over the centuries has contributed much to the present state of his people.

It has, in fact, been observed that California-born Chinese and Japanese actually are better physical specimens than the native-born Asiatics. They eat more in America, too. Then again Gilks and Orr[5] observed that while the Kavirondo of the Victoria Nyanza region have a diet as mixed as the European the prevalent diseases are about the same as those among civilized races. Half the maladies are respiratory; tuberculosis is common and cancer is far from rare. The Mount Kanya natives eat cereals exclusively, with little or no meat, but have poor physiques. The Masai lives on meat, milk and fresh blood but suffers commonly from rheumatism and constipation. A vegetarian diet and abundant sunshine fail to protect the Kikuyu from tuberculosis. Finally, in this incursion into African native diet, the aforementioned Kavirondo follow the curious custom of adding a cow's urine to her milk before drinking it, thus unconsciously augmenting its mineral content.

[4] *Chinese Social and Political Science Review*, January, 1927.

[5] *Lancet*, March 12, 1927, 560.

In passing it is not without interest to emphasize that the following diet seems fundamentally bad—oatmeal, olive oil, milk, meat and yeast, while this one appears experimentally to be basically good—white bread, cod liver oil, milk, meat and yeast!

We turn now to Agnes H. Grant and Marianne Goettsch, fearlessly mentioning the names of original scientific investigators because this is so seldom done. Yet it is much simpler than seeking to avoid mention, it is more honest than posing personally as the original fount of all wisdom and there is no valid reason anyway to deny scientific workers the popular publicity accorded baseball players, adaptive inventors and bankers or industrialists who merely grow rich by commercializing the results of unknown research workers. Let the modest laboratory worker have a name for once![6]

Grant and Goettsch,[7] then, directly studied the nutrition requirements of nursing mothers and the effect of diets deficient in the antirachitic vitamin upon the offspring when mothers eat such diets. McCollum[8] and Hess[9] had separately concluded that if a diet is otherwise satisfactory a mere deficiency in the antirachitic vitamin will not cause rickets when it is fed. Korenchevsky[10] thought otherwise.

There matters stood when Grant and Goettsch attacked the problem and that is why they attacked it. They found that slight dietary deficiencies will, over a considerable period of time, cause diseased conditions which are never produced at all by extreme dietary deficiencies. They found also that the young have rickets only when the antirachitic vitamin is deficient in the diet of their mothers. They demonstrated that the diet of the mother is an exceedingly important factor governing absolutely the increased or decreased resistance of the young to the bad effects of vitamin deficiencies in their own diets. Finally they found that rickets will not develop in young born of well nourished mothers even if these young are actually fed a diet deficient in the antirachitic vitamin.

The rapidity and the severity of the development of rickets in the young really depends very largely upon the depletion of the mother's vitamin reserve during pregnancy. Cod liver oil will actually increase this vitamin reserve while the mother bears and suckles young; the young will then also be very resistant to rickets.

As Cowell[11] observes, it seems apparent that if calcium and the fat soluble vitamins are present in the diet in proper amount rickets may be entirely eliminated, teeth may be vastly improved, infant diarrhoea may be decreased, re-

6 *A note*—In a recent book review appearing in *The Quarterly Review of Biology* the reluctance of scientific popularizers to mention the names of original investigators was observed. Yet the blame lies very largely upon editors and publishers rather than upon writers. Nothing will more quickly and more certainly confound and horrify the editor of even a "quality" magazine than a few references or a few direct quotations from authorities with names attached. The writer is constantly admonished to omit all references and names of authorities and to pose boldly as an authority himself. Editors of so-called quality magazines consistently under-estimate the mentality of their readers on scientific subjects because they project their own literary intelligences beyond where they should extend. Readers are actually not easily shocked by clearly stated scientific facts, but erring editors with their classic abhorrence of science as a thing no cultured gentleman should be able to understand, constantly confess themselves hopelessly bogged in matters any alert high school student could comprehend. Hence the prettified, storyized, weakly humorous, half spoofing, grossly incorrect rot that passes for scientific popularization in the magazines.—T. S. H.

7 *American Journal of Hygiene*, March, 1926, Vol. 6, p. 211.

8 *Proc. Soc. Exp. Biol. and Med.*, 18, 277, 1921.

9 *J. Biol. Chem.*, 47, 395, 1921.

10 *British Medical Journal*, No. 3171, Pg. 547 (1921).

11 *British Medical Journal*, July 31, 1926, 185.

spiratory diseases restricted in virulence and the symptoms associated with malnutrition cleared up. That is simply to say that the diet should contain ample milk, butter and eggs; that there should be constant exposure to sunlight or constant dosage with cod liver oil, which is said to be not so bad if half a banana be eaten immediately thereafter.

We turn to the work of Sherman and MacLeod[12] which at one point contradicts the finding of Mellanby mentioned above. They made a very careful study of the normal calcium content of the bodies of normal rats of different ages and found that the calcium increased in percentage with age. They found that animals fed ample calcium, but stunted in growth by vitamin deficiency, contained more than the normal calcium for rats of the same weight but less than normal for rats of the same age. Furthermore rats fed too little calcium lose calcium from their bones.

Animals fed one sixth whole milk powder and five sixths wheat contained much less calcium than animals fed one third whole milk powder and two thirds wheat, indicating the usefulness of milk as a source of calcium. But unlike Mellanby, these investigators held that the addition of cod liver oil to a diet deficient in calcium would not raise the percentage of body calcium. To do that calcium lactate must be fed in addition to the oil. It is well to record and to attend such differences in order to emphasize the very great complexity of scientific experimentation in nutrition that we may compare therewith the airy and flatulent confidence of the know-it-alls who continuously lecture and write on the subject of diet and disease.

In *The British Medical Journal* for October 25, 1926, there appeared an instructive article by Robert McCarrison, entitled "A Good Diet and a Bad One." This investigator had had excellent opportunities to study middle class diets in England and native diets in India. He fed twenty rats a good diet, such as he says Sikhs eat—whole wheat bread, uncooked cabbage, carrots, fresh fruits, sprouted legumes, potatoes, butter, fresh whole milk and fresh meat. Seventeen lived in good health and of the three which died, two certainly did not die by reason of any nutrition disturbance.

McCarrison also fed twenty exactly similar rats a bad diet, such as Western peoples used—white bread, vegetables cooked in water containing sodium bicarbonate, common salt, a margarine substitute containing 100 grains of boric acid per pound (a common preservative), tinned meat containing the usual chemical preservatives, tinned jam and tea sweetened, then colored with milk. Eleven of these rats died hastily and all were sickly and in poor condition. All these rats suffered from gastro-intestinal and lung troubles and the majority died thereof. McCarrison declares that exactly the same conditions exist among human beings.

Another deficiency causing disease is that of iron. That a young animal is born with a reserve supply of iron is indicated by the fact that its ash will contain about six times as much iron as the ash of the milk fed it in early life. That a diet of milk alone will cause nutritional anemia in young animals beyond the suckling period has repeatedly been observed. That the iron in milk can not be increased by feeding the producing animal additional iron is also well established. Finally it has been demonstrated that iron is readily assimilated from fresh vegetable sources or from inorganic sources if fresh vegetables are also fed. These facts indicate that ample iron supply should be kept in mind in feeding young, growing children so long as milk remains their basic article of diet.

Anemia is, in fact, not an uncommon condition in early life and a little supervision of the diet then will eliminate many illnesses. Outstanding work is

[12] *Jour. Biol. Chem.*, 64, 429, 1925.

being done on pernicious anemia these days by Minot and Murphy and by other investigators. It has, in short, been found that patients with pernicious anemia almost invariably give a history of long continued faulty nutrition and, most fortunately, that the anemia itself may be controlled nutritionally. Using a low fat diet containing fresh fruits and vegetables *ad lib* and much meat, especially kidney and liver, Minot and Murphy rendered nearly all of forty-five pernicious anemia patients absolutely normal and materially helped the remainder. Recent work from McCollum's laboratory indicates that vitamin E, which controls reproduction and is seldom deficient in the ordinary diet, has something to do with the bodily assimilation of iron. If vitamin E is deficient iron assimilation seems to be poor. Liver is unusually high in vitamin E and this may in part explain its efficacy in the regeneration of blood hemoglobin in pernicious anemia.

Whipple and Robscheit-Robbins continued their valuable anemia studies in the December, 1927, *American Journal of Physiology*. They found that the addition of kidney or liver to a diet already rich in iron salts would cause the increased assimilation of iron to be expected from feeding these tissues, but, curiously enough, this increase was always superimposed upon the level of the iron diet. They comment: "It is rare in our experience to find entirely separate factors influencing hemoglobin regeneration which can be combined with complete summation of the two effects." So, bit by bit, the problem of blood hemoglobin regeneration in severe anemia is unraveled.

Another pathological condition that may perhaps be ascribed to faulty diet is stone. Osborne and Mendel suggested in 1917 that stone, or calculi, occurred in the bodies of rats when they were fed a diet deficient in vitamin A.[13] The lack of this fat soluble vitamin seemed to cause a general debility or lowered vitality which favored the invasion of the bladder and urinary passages by bacteria. These bacteria produced an alkaline urine and stones ultimately developed.

Some years later the Japanese Fujimaki[14] apparently confirmed this observation. He found that rats fed a diet deficient in vitamin A developed calculi in the following organs in the order of frequency mentioned—bladder, kidney and bile duct. In some cases the addition of vitamin A to the diet caused the stones to disappear, an argument for milk, butter, eggs and cod liver oil as preventives of stone. It is only fair to say that this work has not yet been pursued far enough to indicate much regarding human beings.

In THE SCIENTIFIC MONTHLY for November, 1927, and in *Popular Science Monthly* for February, 1928, the present writer sought to slay certain common food fallacies. In that article much was said regarding high protein diets and their etiologic rôle in nephritis, constipation and cardio-vascular maladies. Soon thereafter Vilhjalmur Stefansson wrote to the author commending the article but calling attention to the fact that one hundred per cent. meat diets had been fed to human beings without the pathological conditions mentioned developing. As papers in the *Journal* of the American Medical Association for November 23, 1918, July 3, 1926, and May 14, 1927, will show, the Eskimos, a carnivorous race, do not have abnormally high blood pressure, do not suffer unduly from heart and kidney disease and are unconstipated—at least until they adopt the white man's mixed diet. Furthermore, Stefansson himself lived on a one hundred per cent. meat diet for years and survived in excellent health while other men have done this quite success-

[13] *Journal* of the American Medical Association, 69, 32.

[14] "Progress of Nutrition in Japan"—League of Nations Health Organization, Geneva, 1926, p. 369.

fully right here in America. This work is very suggestive and indicates that high meat diets may not be so pernicious to humans as is generally supposed.

Nephritic diets have long been severe in salt and protein limitations. Yet recent work tends to raise these low limits because it has been shown that some albuminuria of such patients is chargeable to tissue losses of protein which simply must be replaced in the diet. Some investigators indeed now advocate very high protein diets for nephritic patients, though more conservative authorities disagree. At any rate the nephritic patient must get enough protein to prevent debilitation through tissue loss.

As to salt in such diseases, indiscriminate salt restrictions are becoming obsolete. During edema, to be sure, it appears that salt should be restricted to two grams daily but an allowance up to five grams is otherwise permissible. Salt retention is found not always to occur in nephritis. Since normal people get from eighteen to twenty-two grams of salt daily, either directly or cooked into their foods, five grams is little enough, but it does alleviate somewhat the nauseous monotony of a salt free diet.

Physicians have long been too prone to prescribe corrective diets too mechanically and often too readily. These diets are seldom tasty and, while a great convenience to the physician, the patient should be considered too. *The Journal of the American Dietetic Association* recently recorded some most amusing experiments carried on at Harvard Medical School by nascent physicians as part of their course. These youngsters actually ate the pallid and lifeless diets often prescribed for patients. The results were enlightening and, we may hope, chastening. In fact, one conscientious youth struggled so hard to absorb a high fat diet that he was reduced to the atrocious necessity of drinking mayonnaise dressing in his coffee; he then so far forgot himself as to declare that any physician who prescribed such a diet was the kind of fool usually relegated to the lost souls division. Doubtless future patients will benefit from this harsh experience on the part of heroic medical students.

As a whole, then, routine diets are as indefensible in disease as in health. Human beings differ; disease syndromes differ. The old adage was correct—one man's meat is another's poison. Certainly corrective diet will under no circumstances cure whatever ails you, though hundreds of mail order quacks and lecturing faddists endeavor to make you think so.

We have found, however, that nutrition is an important consideration in preventive medicine. Not only does faulty food cause such avowedly "deficiency diseases" as scurvy, beri beri, rickets, optical inflammation (ophthalmia) and pellagra, but gastro-intestinal and respiratory diseases, anemia and even stone may arise from dietary inadequacy. Moreover the faulty diet of mothers is visited upon the next generation in the form of lowered resistance to disease. We have every reason to keep the mysterious internal alchemist, as Paracelsus called him, not only appeased, but supplied with an abundance of best quality raw material.

Many years ago the great Paracelsus wrote:

> The alchemist in each one of us is clever at his business, and just as a prince knows how to employ the best qualities of his servant while leaving the others alone, the alchemist uses the good qualities of our food for nourishment and expels those that would harm us. The alchemist dwells in the stomach, where he works and cooks. He takes the good and changes it into a tincture which he sends throughout the body to nourish all that is in it.

Therefore, the more good qualities the hypothecated alchemist can find the better for us.

RACIAL GROUPS IN A UNIVERSITY

By Professor EDWARD CARY HAYES

THE UNIVERSITY OF ILLINOIS

In view of the discussion of racial traits by a great company of writers, from Gobineau and Vacher de Lapouge to Wiggam and Madison Grant, and in view of current fears as to the mongrelizing of our stock, it occurred to the writer to study the racial groups represented in the University of Illinois. The number of students is sufficiently large to have significance. The individuals are tested for four years in similar pursuits. They come after twelve years of similar schooling. Against such a background of cultural similarity, racial traits might be expected to stand out definitely.

The university department of hygiene which examines every student admitted was asked to record for each student the measurements from which cephalic index is computed, eye color and hair color, distinguishing a number of grades of each, stature, build and racial parentage, as understood by the matriculant.

After thousands of these records had accumulated, a graduate student, Mr. George M. Proctor, was asked to sort out the records of the first hundred Nordics, the first hundred Alpines, the first hundred Mediterraneans, and of all the Chinese, other foreigners, Jews and Negroes encountered. However much doubt there may be as to whether his Nordics, Alpines and Mediterraneans are actually pure-bred representatives of distinct racial stocks, there is no doubt that they are as distinctly classifiable by race as white American citizens ever are.

The investigator was directed to give primary importance to cephalic index and secondary importance to eye color. Hair color and stature were recognized as less significant but treated as corroborative evidence when, for example, blond hair and high stature accompanied a dolicocephalic index and blue eyes, or when medium stature, stocky build and chestnut hair accompanied a brachycephalic index and hazel eyes. The race of their parents, as given by the students, and their names were also treated as having some corroborative value.

The first result of his investigation was that relatively few of the students at this university could be definitely assigned to any racial group. Our student population is very thoroughly mixed in blood and is descended mainly from European populations, each of which is very mixed.

The second fact disclosed was that of those who could be so classified an overwhelming majority were Nordics. Mr. Proctor classified as Nordics about one tenth of the first thousand, but after going through the records for eleven thousand students, he had found only seventy-two whom he felt confident in classifying as Alpines and only ten whom he could classify with confidence as Mediterraneans. Italian parentage and name were not proof of membership in the Mediterranean race. There is too much Lombard and Alpine blood in Italy, and too much departure from characteristic Mediterranean traits was found among those who call themselves Italians.

The Jews were a racially heterogeneous group. Thirty-four per cent. of them had gray, blue or greenish eyes, two had red hair. In respect to cephalic index they were distributed pretty evenly all the way from 72.5 to 88.6, that is, from those very decidedly doli-

cocephalic, through sub-dolicocephalic, meso-cephalic, sub-brachicephalic, to very decided brachicephalic. They showed no tendency to center about a cephalic type. Many of the Jews are indistinguishable in appearance from other Americans. Others among them "look Jewish," that is foreign. The foreignness is often Syrian or Hittite, rather often Spanish. So far as this group of ninety-three indicates, they do not represent a racial type.

The 435 students included in the seven groups treated as classifiable had a scholastic average distinctly below that of the racially unclassifiable mass of students in the university. In this institution a student's grade is computed by counting a grade of A equal to 5, B equal to 4, C equal to 3, D equal to 2 and E equal to 1. E is failure. Each course grade is multiplied by the number of hours' credit given for the course. The sum of these products is divided by the student's total number of credit hours to give his average grade. The average of all the men in the university is found each semester by averaging the averages of a thousand men selected at random. In the nine semesters ending January, 1925, the average grades of all men has ranged from 3.157 to 3.314. The average of the nine semesters has been 3.235.

The 435 students belonging to classifiable groups taken together had for the entire time of their residence at the university an average scholastic grade of 2.934. To one familiar with our grading system this is a marked inferiority.

The seven classifiable groups had the following averages:

Chinese	3.35
Jews	3.18
Nordics	3.00
Foreign students, excluding Chinese	3.00
Alpines	2.94
Mediterraneans	2.83
Negroes	2.55

Only the Chinese equal the average for unclassified men.

The ten individuals among the 435 classified having the highest grades were:

A Nordic	4.94
A Chinaman	4.82
A Jew	4.73
A South African	4.68
A Nordic	4.68
A Nordic	4.65
A Chinaman	4.48
A Chinaman	4.47
A Jew	4.41
A Negro	4.29

The first six in the above list have grades entitling them to election to Phi Beta Kappa or Tau Beta Pi. No others of the 435 classified are clearly eligible to such election. Three per cent. of those classified as Nordic appear in the list of ten best students, 8.33 per cent. of the Chinese, 2.15 per cent. of the Jews, 1.57 per cent. of foreigners, excluding Chinese, 1.66 per cent. of the Negroes, no Alpine and no Mediterranean. In the case of the Mediterraneans, at least, the number involved is too small to have any significance.

In view of the alarms that have been sounded as to the degeneracy to be expected from hybridization, perhaps the most interesting of these facts is that the aggregate of 435 classifiable students, including thirty-six Chinese slightly superior to the average, should be so distinctly lower in scholastic standing than the unclassifiable mass. The hundred Nordics are decidedly below the average of unclassified students. So are the Jews.

The figures given are reported merely as a bit of evidence to be put with other evidence for what it may be worth.

THE PURPOSE AND PROGRESS OF OCEAN-SURVEYS[1]

By J. P. AULT

COMMANDER, YACHT *Carnegie*, CARNEGIE INSTITUTION OF WASHINGTON

THE oceans occupy so large a part of the earth's surface that knowledge of their contents and physical conditions is of prime importance. Especially is this true for certain problems relating to the physics of the earth as a whole—geophysics. Human life and its environment and the evolutionary processes in the living world are influenced in countless ways by the varying physical properties of the ocean.

In the geophysical sciences with which we are concerned to-night, terrestrial magnetism, terrestrial electricity, and oceanography, much information has been collected already, though systematic investigations are but fairly started and the vast extent of the oceans still leaves many unsolved problems.

Our knowledge of the origin of the earth's magnetic and electric field is still imperfect. The exact interrelation between these two fields is not known, and we are interested in securing more information regarding the close connections which seem to exist between variations in magnetism, atmospheric electricity, auroral displays, earth-currents and transmission of wireless waves. Observations over the comparatively undisturbed ocean areas will very materially aid in the discussion of all these phenomena.

The history of ocean magnetic surveys goes back to the time of Columbus, who is credited with the discovery of the magnetic variation or declination. This is the angle between the true or astronomic meridian and the magnetic meridian. As is well known, the magnetic compass does not point toward the geographic poles, but toward the magnetic poles of the earth, the north magnetic pole being located somewhere north of Hudson Bay and about 1,000 miles from the true pole.

The steps in the development of the compass from a loadstone floating on a piece of wood in a vessel of water to its present form are not fully recorded. It apparently was used by the Chinese for navigational purposes as early as the fourth or fifth century and by the Europeans as early as the twelfth century. To Columbus we trace the first distinct step in removing from vague superstition the real cause governing the directive action of the compass.

The dramatic and epoch-making events of Columbus's first voyage to America in 1492 have been repeated often, but their significance in the early history of the compass may excuse a recounting of some of the details at this time. When seven days out from the Canary Islands, Columbus wrote: "On this night the needles turned to the northwest, and in the morning they turned more northwest." Four days later he wrote: "The pilots marked the north and found that the needles had turned to the northwest a full point ($11\frac{1}{4}°$). The mariners were alarmed and anxious but did not say why. The Admiral (Columbus) knew and ordered them to return to mark the north again in the morning and then the needles were found true. The cause is that the star (North) appears to make the movement and not the needles."

[1] Address delivered on November 22, 1927, at the Carnegie Institution of Washington, Washington, D. C.

Up to the time of Columbus it was thought that the compass pointed to the true north at all places. It was the common practice to mount the card on the needle in such a way that the compass showed true north for any one particular locality. If the compass was used in another locality, then the card was shifted the proper amount to again indicate true north. The difference was ascribed to an error inherent in the particular needle used. In this case Columbus, to quiet the fears of his company, undoubtedly shifted the card on the compass so that in the morning it indicated true north again.

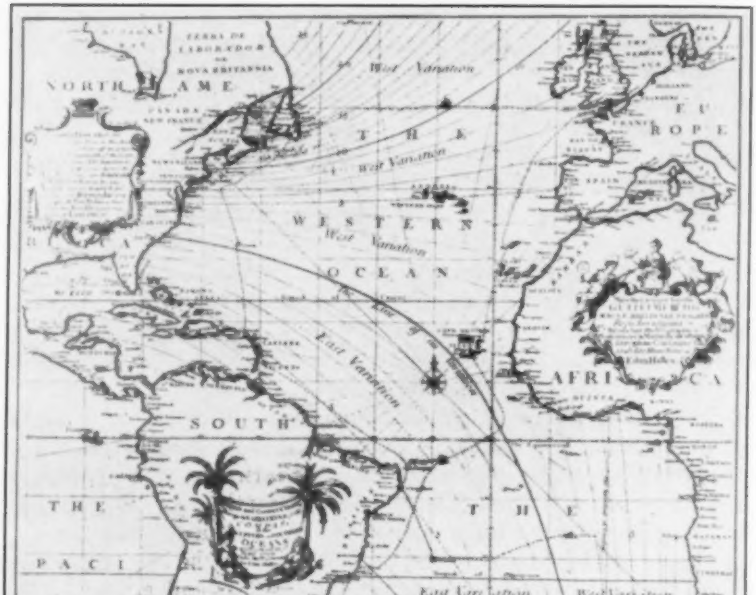
He had shifted the compass card on a previous voyage, for in 1460 when near Sardinia and an unruly ship's company wished him to take them to Marseilles for aid Columbus writes: "Being unable to force the crew's inclination I yielded to their wish and, having first changed the points of the compass, spread all sail, for it was evening and at daybreak we were within the Cape of Carthagena while all believed for a certainty that they were going to Marseilles." He also made a practice of entering in his log book the day's run as considerably less than the leagues actually sailed so as not to alarm his crew by the great distance back to Spain. These events shed an interesting light on the status of the men in sailing-ship crews in the early days. They were all adventurers together, and all seemed to know just where they were going and were aware of the compass course to be followed.

Columbus was a resourceful leader, and that he was an expert navigator with an excellent knowledge of sailing conditions in the North Atlantic is shown by the fact that the route he selected is exactly the same that would be selected to-day to make the same voyage. Before departure from the Canary Islands he changed the rig of one of his ships from fore-and-aft to square rig, showing that he knew he was to sail in the region of the "trades" with fair wind. During the remainder of the first voyage he makes no mention of the compass, apparently depending upon the same "movable" north star for his direction and guidance. However, during his third voyage he again records the fact that not long after leaving the Canary Islands the compass again turned to the northwest a full point, thus confirming the first discovery that the compass changes its pointing from place to place.

There is evidence that Columbus attempted during his return voyage to use this variation of the compass to help determine his position in longitude. Before the invention of accurate timepieces, navigation consisted in observations of the noon altitude of the sun for latitude and crude estimation of course and distance to determine longitude. This method was very unsatisfactory, since unknown ocean-currents and errors in reckoning made it impossible to keep accurate account of the ship's position. Edmund Halley, the noted astronomer, at one time was over 300 miles out of his reckoning on one of his famous voyages in 1698–1701.

Large prizes were offered for a more reliable method of determining longitude, and in 1698 Halley began his voyages in the Atlantic Ocean on the *Paramour Pink* to "improve the knowledge of the longitude and variations of the compass." As a result of these voyages he constructed and published the first magnetic chart of the oceans, and his method of drawing lines through points of equal declination is still used in nautical charts to-day. His map was used for many years, not to determine the longitude, the purpose for which it was constructed, but to give the navigator his compass correction as he sailed from port to port.

Halley used a very simple method to determine his compass variation, merely



HALLEY'S ATLANTIC CHART OF THE LINES OF EQUAL MAGNETIC DECLINATION AS BASED ON HIS OBSERVATIONS MADE DURING THE CRUISE OF THE "PARAMOUR PINK," 1698-1700.

[The dotted lines show the tracks followed by Halley's vessel.]

HALLEY'S ATLANTIC CHART.

taking the amplitude of the sun, *i.e.*, its compass bearing when on the true horizon, in the evening, and again in the morning, one half the difference between these two bearings being the compass variation at midnight. Over 200 years later we were able to add many values to the declinations which he observed by computing for him the results of his observations taken on the sun when that body was at some altitude above the horizon.

A comparison of the early maps showing the compass variation with our most recent ones will show the changes which have taken place in the 200 years between the voyages of Columbus and Halley and in the interval of 200 years to the present time. It is readily seen why Halley's scheme to determine longitude by means of a magnetic chart failed of its purpose because of the changes constantly taking place in the compass pointing. Halley himself knew of these changes and cautioned the users of his chart to take them into account.

To give some idea as to the amount of these changes, it might be noted that our two cruises in the Indian Ocean in 1911 and 1920 showed that the compass was

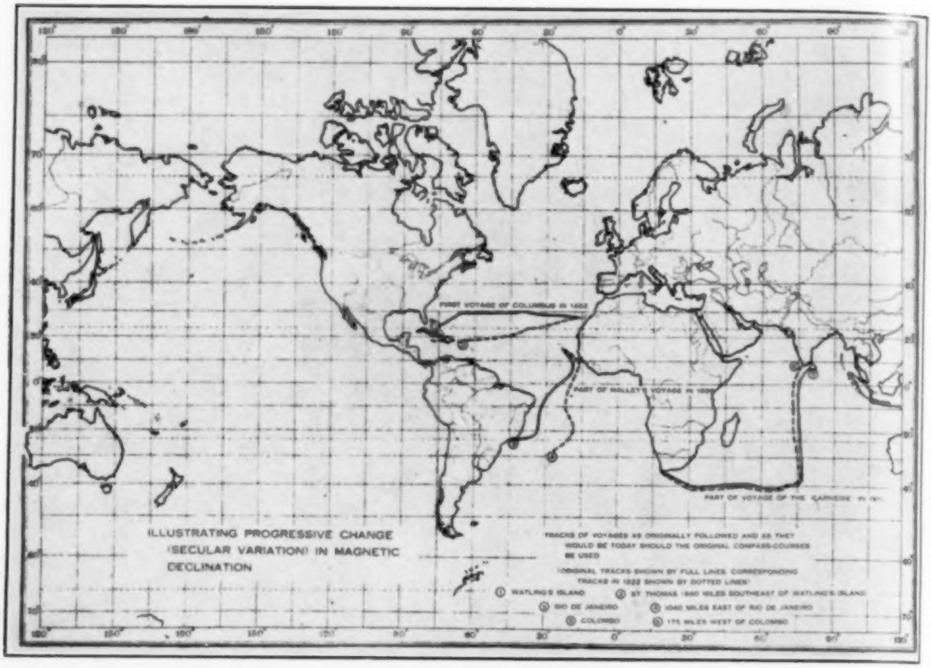
changing its direction over one third of a degree annually in the central part of the ocean. In 1911 the navigational charts for this ocean were in error by as much as one half point, chiefly owing to lack of accurate information as to the amount of the annual change. In 1580 the magnetic needle pointed 11° east of north at London and by 1812 it pointed 24° west of north, a change of 35° in 232 years. It now points only about 16° west of north. The causes of these changes and variations are not as yet known, and their explanation constitutes one of the chief problems in the science of terrestrial magnetism.

It is with these changes that we are chiefly concerned in a study of the earth as a magnet in trying to explain the origin of the earth's field, the causes of the changes which are observed during the day, the variation with the seasons during the year, and the secular or progressive change from year to year. We also wish to know why there is such close relation between changes in terrestrial magnetism known as magnetic storms and the occurrence of polar lights or auroras, both north and south, and changes in solar conditions, and why we have eleven-year periods in magnetic changes and disturbances coincident with the well-known eleven-year periods in sunspot activity.

Since we can not bring the earth into the laboratory and study its problems, we must go out over its surface, penetrate into its interior, into its atmosphere, and into the ocean depths as far as present inventive genius will permit, and observe and record the results of experiments which nature is performing on a cosmical scale.

In order to secure the data necessary for a complete study of these various problems in magnetism, it was decided early in the organization of the magnetic-survey work of the Carnegie Institution of Washington to extend the investigations to the large ocean-areas. Since the time of Halley in 1700, occasional magnetic observations have been made at sea incidentally on voyages of discovery and exploration, as those of the *Erebus* and *Terror*, the *Pagoda*, the *Challenger*, the *Discovery*, and the *Gauss*. But over 200 years elapsed after Halley's survey before another expedition started out primarily to make magnetic observations at sea. The *Galilee* sailed out of the Golden Gate in 1905 to survey the Pacific Ocean, making three cruises during the period August, 1905, to June, 1908. On these expeditions, the fruition largely of the plans and vision of Bauer and his colleagues, observations were made not only to determine the magnetic declination but also the magnetic dip or inclination and the strength of the earth's magnetic field. The instruments used in these observations were mounted on an open bridge exposed to wind and weather, and many doubted whether worth-while observations could be made at sea with equipment then in use.

The accuracy of the results with these more or less experimental instruments and the promise of increased accuracy with new devices invented and constructed by Peters and Fleming indicated the desirability of continuing the ocean-survey. At the same time the effect of what little iron was present in the hull of the *Galilee* was so difficult to control and measure in the results that it was decided to construct a specially designed nonmagnetic vessel. In 1909 the *Carnegie* was completed and began her long series of cruises in August of that year. Reference to the map will show the extent of these cruises for the period 1905 to 1921; 3,316 declination and 2,147 inclination and horizontal intensity stations were occupied. Improvements in the instrumental equipment increased materially both the amount and the accuracy of the data secured. Since advancement and success of ocean-surveys are measured by progress in the development of instru-



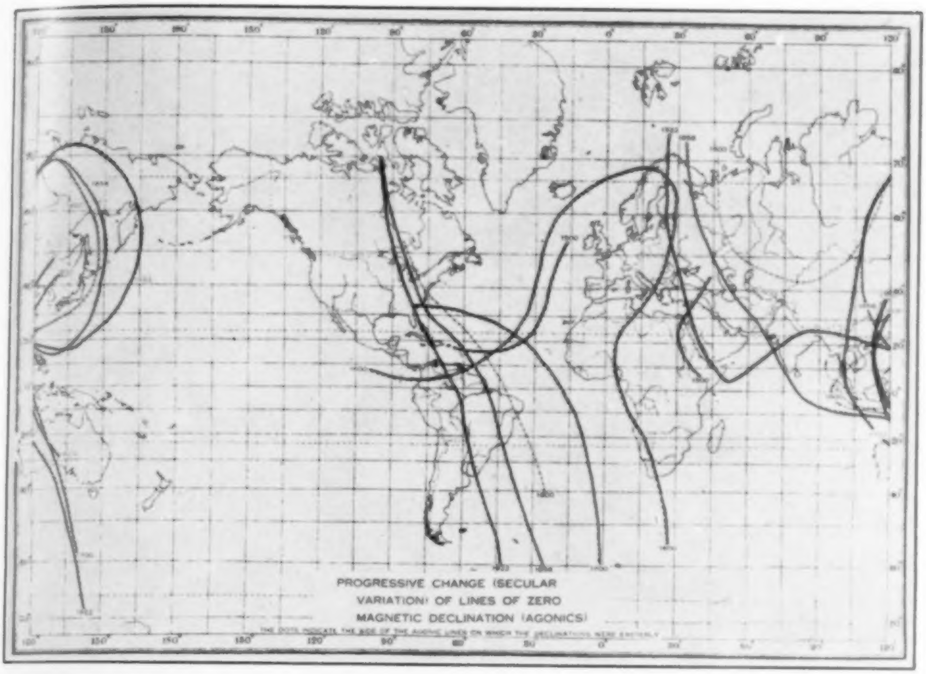
PROGRESSIVE CHANGE (SECULAR VARIATION) IN MAGNETIC DECLINATION.

mental equipment, full credit must be given to those who have developed this phase of the ocean-surveys executed on the *Galilee* and the *Carnegie*.

A very satisfactory distribution of stations has been accomplished, and the accuracy of present-day magnetic charts used by navigators has steadily increased since the various hydrographic offices began using the data resulting from these surveys.

At only about eighty stations do we have cruise-intersections where reliable information has been obtained regarding the changes which have taken place over a period of years, the so-called secular variation. To improve this condition, in future ocean-survey work it is planned to retrace previous cruises and reoccupy as many points as possible in order to secure the maximum data on the amount and direction of this secular variation. This will furnish valuable information for keeping navigation charts up to date as well as supplying the necessary data for the advancement of theoretical studies and investigations.

The study of the earth's electric field, that is, of terrestrial electricity and including both atmospheric electricity and earth-currents, is now being carried forward side by side with the study of the earth's magnetism. The importance of these investigations has increased in recent years because of the close relation between variations in atmospheric-electric and earth-current phenomena and variations in magnetic conditions. Recent theories regarding the nature of electricity and the constitution of matter and the rapid advances made in radio transmission have given added stimulus to the study of the earth's electric field. The sun is included in this study because of the close connection between magnetic and atmospheric-electric phenomena and solar activity, and cooperative work with the Mt. Wilson Solar Observatory in these investigations was started last year.



PROGRESSIVE CHANGE (SECULAR VARIATION) OF LINES OF ZERO MAGNETIC DECLINATION (AGONICS).

Some experimental observations in atmospheric electricity were made in 1908 on the *Galilee* and in 1909 to 1914 on the *Carnegie*, but it was not until 1915 that a systematic and definite program of observations was undertaken with new and improved methods and instruments devised and constructed chiefly by Swann and Fleming. A well-known European student of atmospheric electricity states that the only new contribution to this science within the past ten years was that resulting from the cruises of the *Carnegie*, which is especially valuable because of the wide distribution of information obtained.

The electric elements which have been investigated include potential gradient, both positive and negative ionic content, conductivity, and ionic mobility, penetrating radiation, and radioactive content of the air. The potential or electric charge in the air increases with height above the earth's surface, being about 100 volts at the height of one meter. This is the so-called potential gradient and is measured by noting the deflection on the fibers of an electrometer while the collector is raised one meter. There are present in the air at all times both positively and negatively charged particles called ions, about 1,000 of each kind in a cubic centimeter of air, and with our instruments it is possible to count the number with fair accuracy. Intimately connected with the number of ions in the air is the electric conductivity, or its ability to carry an electric current. Air is forced past a charged conductor at a uniform rate of speed, and the rate of discharge is noted by the changing position of the fibers in an electrometer.

Whether penetrating radiation or "cosmic rays" coming into the earth's atmosphere from outer space can be one of the causes of the ionization of the air is one of the problems being investigated, and observations are made at sea to determine the amount and variation of this radiation by observing the rate of

THE *Galilee*. (DURING THREE CRUISES IN THE PACIFIC OCEAN, 1905–1908, THIS VESSEL COVERED OVER 73,000 MILES.)

ionization in a closed copper vessel. The radioactive-content observations are arranged to collect and measure the amount of radioactive material, such as radium and thorium, present in our atmosphere, this being another source of ionization.

Under the action of the earth's electric field, positive ions are traveling toward the earth and negative ions are traveling upward into the air, giving rise to an air-earth electric current. The rate at which this interchange takes place would neutralize the earth's negative charge in a very short time were there no recharging source of energy. Various theories have been advanced to account for the source of this supply, *e.g.*, lightning, the sun, but the problem still awaits solution.

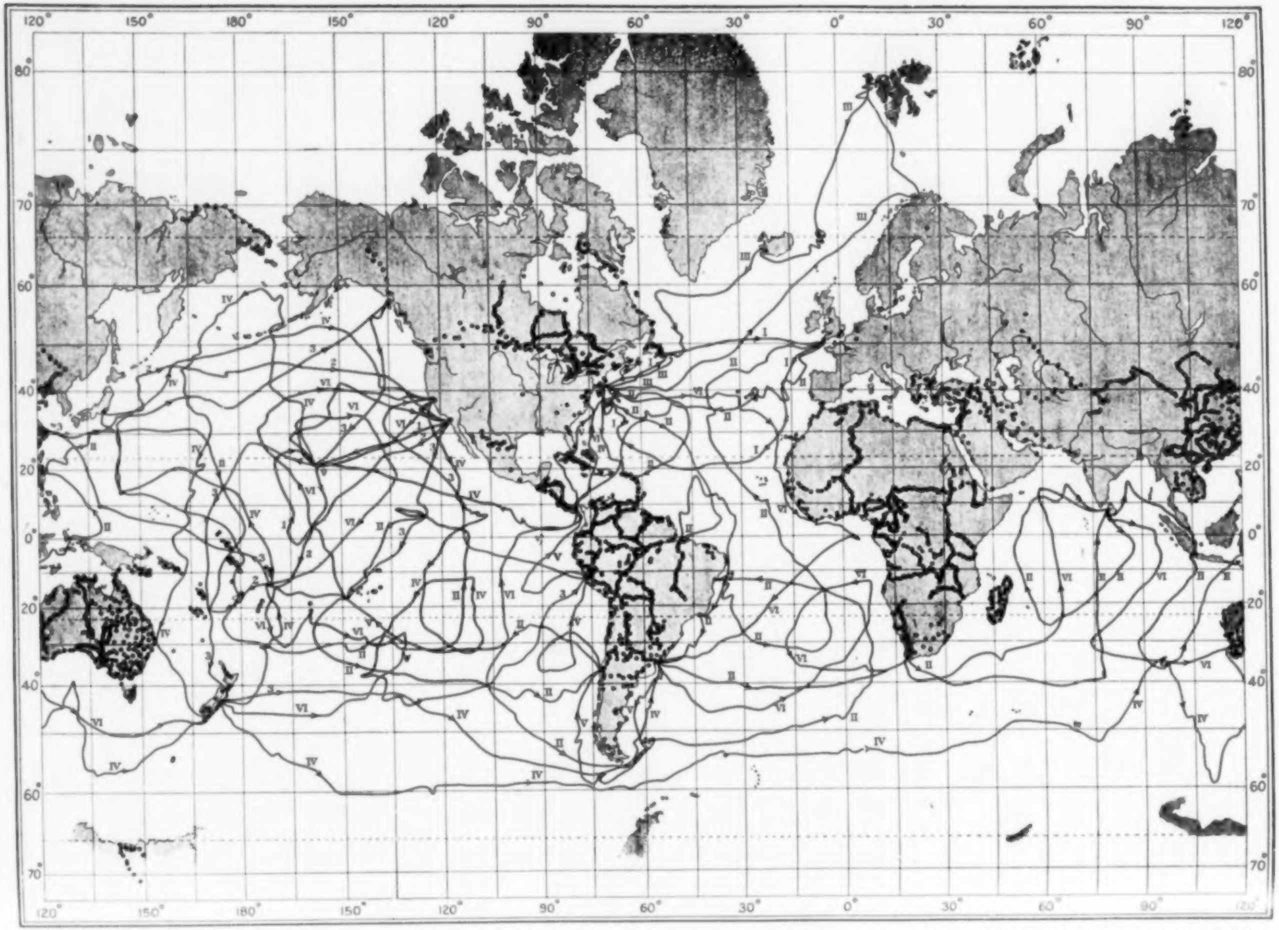
Conditions at sea are much more favorable for investigating the earth's electric field than on land, where dust and smoke in the air and presence of changing cultural or permanent topographic features such as trees, buildings or contours cloak the true characteristics of the atmospheric-electric phenomena. To further improve the atmospheric-electric results and to note the conditions at sea, dust-count observations are to be included in the program since it is known that the presence of dust in the air has a marked influence upon atmospheric-electric conditions.

In order to determine the variations which take place in the earth's electric field during a twenty-four-hour period, continuous observations of the changes in these elements are carried out on the

NONMAGNETIC YACHT *Carnegie* OFF PORT LYTTELTON. (DURING SIX CRUISES IN ALL OCEANS, 1909–1921, THIS VESSEL COVERED OVER 291,000 MILES.)

Carnegie at frequent intervals. I will but mention the difficulties of carrying out such observations under conditions which persist at sea, insulation troubles due to condensation and to salt spray, and difficulties attending the use of instruments on a rolling ship. In dealing with insulation difficulties we have learned that our favorite slogan "Electricity never fails" has always held true. The instrument will always work if the insulation surfaces are clean and all connections are good.

A discussion by Mauchly of these twenty-four-hour series of atmospheric-electric observations at sea on the *Carnegie* disclosed that the chief maximum of the diurnal variation of the potential gradient occurs at about 18^h Greenwich mean time all over the world, approximately the time when the sun is in the meridian of the north magnetic pole. This conclusion was confirmed by Sverdrup during Amundsen's Arctic-Drift Expedition on the *Maud*. The true physical explanation of this discovery is not yet apparent. Wait and Sverdrup point out that the rotating magnetic field of the earth induces electromotive forces in the earth's electric field, the variations of which are in remarkable agreement with the observed variations of the potential gradient over the oceans. This agreement appears too good to be accidental, but further evidence is needed for a satisfactory physical interpretation. To add to the information regarding variations of the potential gradient, an automatic photographic recording electrometer is to be mounted near the truck of the mainmast during the next cruise. Some experi-



Magnetic-survey work of the Department of Terrestrial Magnetism during the period 1905–1926. (Cruises of the *Galilee* are indicated by Arabic numerals, those of the *Carnegie* by Roman numerals; black dots show the land stations.)

OBSERVING MAGNETIC DECLINATION WITH COLLIMATING-COMPASS ON BRIDGE OF *Carnegie*.

mental work with this apparatus was done during the return of the *Carnegie* from New York to Washington last month by W. C. Parkinson, who will have charge of the atmospheric-electric work during the next cruise.

The important contributions to the study of various geophysical problems which are being made by investigations of the Kennelly-Heaviside conducting layer and of radio transmission and variations with changing magnetic and electric conditions greatly enhance the value of the ocean atmospheric-electric data and indicate cooperative investigations along similar lines for future ocean-work. It is planned to begin at sea investigations of the conducting layer and to carry out experiments on the variations of signal-intensity, following methods already in use on land.

Important correlations between earth-current variations and changes in other geophysical and cosmical phenomena, such as solar activity, magnetic disturbances, and polar lights, have resulted from an investigation of observatory records, and the importance of these studies in the general study of the earth's magnetic and electric fields now warrants beginning systematic earth-current observations at sea. Some preliminary experimental work was done while the *Carnegie* was *en route* from New York to Washington this year in order to determine best methods and instruments for such investigations over the oceans.

The challenge of the vast, practically unknown expanse of the atmosphere above the earth's surface and of the equally unexplored depths of the ocean awaits the pioneering spirit of a Langley or the ingenuity of a Lord Kelvin to penetrate their mysteries. When inventive genius makes it possible to investigate the modifications in magnetic and electric variations due to change in alti-

OBSERVING MAGNETIC DECLINATION WITH DEFLECTOR-COMPASS IN AFTER DOME OF *Carnegie*.

tude, many new and important discoveries will be made.

The mysteries of the ocean-depths, however, are slowly being unfolded through advances in the growing science of oceanography. This science has been defined as "comprehending the investigations which deal with the form and divisions of all the marine areas on the surface of the globe, the winds that blow over the surface waters, the contours of the ocean-bed from sea-level down to the greatest depths, the temperature, the circulation, the physical and chemical properties of sea-water, the currents, tides, and waves, the composition and distribution of marine deposits, the nature and distribution of marine organisms at the surface, in the intermediate waters, and on the floor of the ocean, as well as the modifications brought about in living things by the conditions of their existence, the relation of man to the ocean in the development of commerce, fisheries, navigation, hydrography and marine meteorology. All this vast assemblage of knowledge, which embraces some aspects of astronomy, geography, geology, physics, chemistry, and the biological sciences, makes up the modern science of oceanography."

Up to the time of the *Challenger* expedition in 1872 to 1876, oceanographic research had been limited to restricted areas, or was incidental to some exploratory expedition, or was associated with some national fisheries investigations. Following the stimulus given by the *Challenger* results, oceanographic investigations were much extended, and new methods and instruments were devised. However, the vastness of the regions to be explored and the time and expense entailed in sending instruments to the bottom of the ocean-deeps leaves many unsolved problems for the oceanographer. Time does not permit more than a brief mention of the pioneer work done by Forbes, Thomson, Agassiz, Murray and others who laid the foundations of the present science of oceanography.

In spite of all the vast amount of data that has been collected, we have only a general idea of the contours of the ocean-

OBSERVING MAGNETIC INCLINATION WITH DIP CIRCLE IN FORWARD DOME OF *Carnegie*.

OBSERVING ELECTRIC POTENTIAL-GRADIENT WITH SPECIAL COLLECTOR AND ELECTROMETER AT STERN OF *Carnegie*.

bed and only a meager knowledge of the bottom sedimentary deposits which are of peculiar interest to the geologist in his study of the age and formation of the earth and the changes which time has witnessed. The mapping of the configuration of the oceanic basins covering over two thirds of the earth's surface should be as important as the mapping of the land masses which occupy less than one third. Such information is necessary for the geodesist in his study of the movements within the earth's crust and for the seismologist in his study of the origin, history and probable future development of submarine earthquakes.

The movements of vast bodies of water relatively to one another and to the land due to winds and tide and the vertical movements due to changes of temperature and salinity make the ocean with its vast capacity for carrying heat a powerful factor in its influence upon practically every phase of life upon the earth, in its control of climate, and in its determining effect upon man's migration and habitation.

Perhaps the most fascinating study connected with the sea is the multitudinous life found in all oceanic waters from the surface down to the deepest abyss yet explored. Physical changes in the ocean-waters have profound influ-

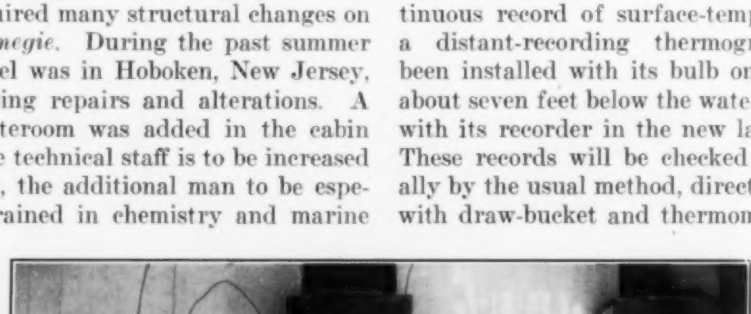
ences upon marine life, its variety, its amount, and its distribution. A knowledge of these influences will contribute in many ways not only to the study of evolutionary processes taking place in the sea but to the practical problem of economic use of the ocean's food resources.

Many problems of oceanography are of interest to the Carnegie Institution of Washington through the activities of its various departments and research associates. The vast extent of the ocean-areas to be covered by the next cruise of the *Carnegie* offers unique opportunity to add new and much-needed information in this science from regions never investigated.

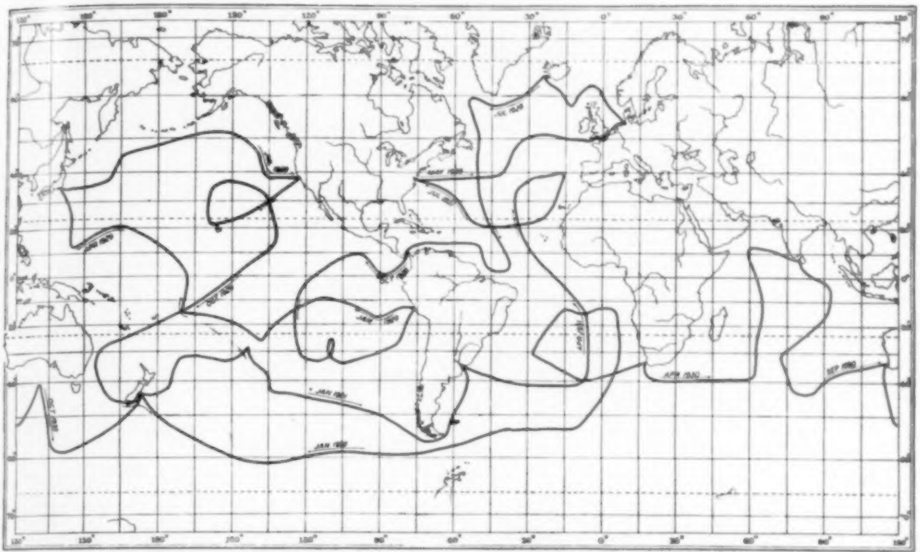
To carry out the proposed increased program of general oceanographic work has required many structural changes on the *Carnegie*. During the past summer the vessel was in Hoboken, New Jersey, undergoing repairs and alterations. A new stateroom was added in the cabin since the technical staff is to be increased to seven, the additional man to be especially trained in chemistry and marine biology. The two lifeboats were moved from the quarter-deck to overhead platforms amidships opposite the after dome, leaving the quarter-deck free for the operation of the bronze winch, sounding wire, and special davits for handling tow-nets, water-bottles, deep-sea reversing thermometers and bottom-samplers.

Two new laboratories were constructed on deck; one will be specially fitted for physical oceanographic, biological and chemical work, and the other will house the radio and echo-sounding equipment.

In physical oceanography it is planned to obtain temperatures and water samples at depths of 5, 25, 50, 75, 100, 200, 300, 400, 500, 700, 1,000, 1,500, and 2,000 meters every 150 to 200 miles, with occasional series down to the bottom with a limit at 20,000 feet. To obtain a continuous record of surface-temperatures, a distant-recording thermograph has been installed with its bulb on the hull about seven feet below the water-line and with its recorder in the new laboratory. These records will be checked occasionally by the usual method, direct readings with draw-bucket and thermometer.



ATMOSPHERIC-ELECTRIC INSTRUMENTS IN OBSERVATORY ON *Carnegie*. (LEFT TO RIGHT, ION COUNTER, PENETRATING-RADIATION APPARATUS, AND RADIOACTIVE-CONTENT APPARATUS; THESE INSTRUMENTS ARE SUSPENDED IN GIMBALS SUPPORTED FROM OVERHEAD.)

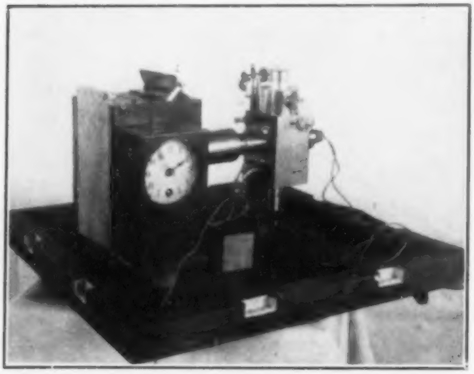


TENTATIVE ROUTE FOR SEVENTH CRUISE OF THE "CARNEGIE," 1928–1931

Water samples and temperatures will be secured by Nansen water-bottles and Richter reversing deep-sea thermometers, using a series of ten on the wire at one time. The water-bottle has a capacity of 1¼ liters, and two thermometers will be used with each one in order to check the temperature. The salinity and density of each water-sample will be determined on board ship by the Wenner electric conductivity method and checked occasionally by the silver-nitrate titration method. The water-sample also will be analyzed chemically for oxygen, nitrate and phosphate content, and hydrogen-ion concentration.

Samples of muds and sediments from the bottom will be secured by use of the snapper-type of sampler, as modified by Vaughan, and a larger Eckman tube-sampler, as modified by Trask for deep water. It is now known that bottom-living creatures feed on organic matter found in bottom muds, and that these muds are often teeming with life. From a study of these organisms and fossil remains, together with borings from oil-wells, important conclusions have been reached regarding the origin of oil-producing deposits. The Geophysical Laboratory also is interested in the nature and derivation of inorganic marine deposits in the study of the age of the earth and the various processes of its formation.

The machinery necessary to handle water-bottles, thermometers and bottom-samplers has been installed on the *Carnegie*. It consists of a 30-H. P. gasoline engine and a 12-KW generator installed below decks in the engine-room to furnish the required electric power A bronze winch weighing three tons, operated by a 15-H.P. electric motor, has been installed on deck. Two reels and two gypsy-heads are provided, one reel containing 20,210 feet of special aluminum-bronze stranded wire rope, 3/16-inch or 4 mm. in diameter, and the other containing 6,808 feet of ¼-inch or 6-mm. wire. This wire was made in Germany and was designed especially for oceanographic work after extensive tests and experiments by those in charge of preparations for the German Expedition on the *Meteor,* 1925 to 1927.



AUTOMATIC PHOTOGRAPHIC-RECORDING ELECTRIC POTENTIAL-GRADIENT RECORDER TO BE MOUNTED NEAR THE TRUCK ON TOP OF MAINMAST OF *Carnegie*.

The gypsy-heads are to be used in handling yards, sails, hoisting lifeboats, hauling in earth-current cables, and for the general work on deck. Special bronze davits and blocks have been installed for handling the wire as it is played out or hauled in. Platforms have been constructed on both port and starboard sides, where the observer will stand while attaching or detaching the water-bottles and thermometers to the sounding wire.

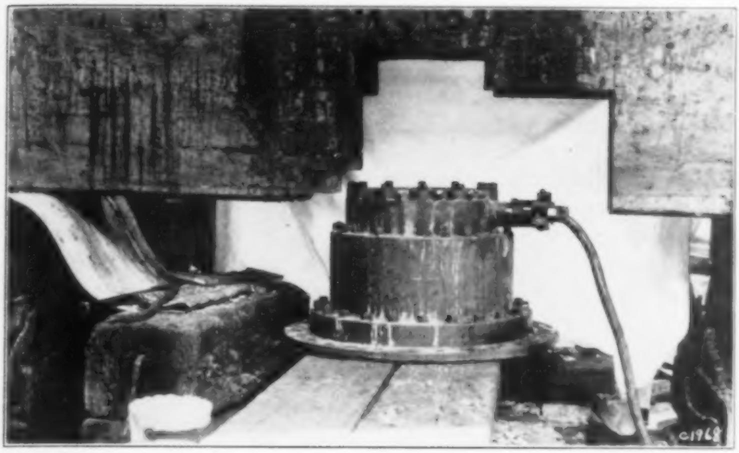
The winch has been constructed so that the reels may be operated either singly or together, thus allowing one wire to be played out on the brake while the other wire is being hauled in. This will allow two series of water-bottles to be operated simultaneously, thus saving materially in the time required at each station.

It is planned to heave to every other afternoon, taking in all sails except those required to keep the vessel as nearly stationary as possible. To keep the wire vertical or nearly so will require skilful maneuvering, and it may be necessary to use the main engine occasionally to accomplish this result. Helland-Hansen and Nansen have carried out similar work with great success on the *Armauer Hansen*, a sailing vessel of only one half the size of the *Carnegie*. They state that[2] "owing to its special construction the ship is easily maneuvered in such a manner that the line along which the oceanographic instruments are suspended remains in a vertical position throughout the time of observation even if there is a strong drift caused by wind or current." This is essential in order to obtain correct depths by wire measurements.

As a further aid in checking the depths at which temperatures and water-samples are obtained, simultaneous use is to be made of protected and unprotected thermometers, calibrated for pressure-effects, placed at frequent intervals as the wire is lowered into the water. The difference between the readings of the two thermometers at any level will give the depth for that level. This method was used recently with success by the German Atlantic Expedition on the *Meteor*. To avoid rapid and excessive drift of the vessel when hove to in a strong breeze, sea-anchors will be used to check the headway. Simultaneous determinations of depths with actual wire soundings and with the echo-method, together with temperature and salinity data at all levels, will give information of great value in establishing proper formulae for the velocity of sound in sea-water in the deep basins of the ocean.

The latest type of sonic depth-finder as developed by Harvey C. Hayes has been installed on board the *Carnegie*, and frequent determinations of ocean-depths will be made as the vessel is proceeding on her way. The depth can be determined in a very few moments, the method consisting essentially of measuring very accurately the time-interval between a signal sent out from the ship and the return of the echo from the bottom of the sea. The United States Navy

[2] Helland-Hansen and Fridtjof Nansen, The Eastern North Atlantic, Geofysiske Publikasjoner, 4; (2) 3–4 (1926).



OSCILLATOR BEING INSTALLED IN KEEL OF *Carnegie* FOR TRANSMITTING SIGNALS IN MEASURING OCEANIC DEPTHS BY THE ECHO-SOUNDING METHOD.

is cooperating in this work by lending the necessary equipment consisting of an oscillator for transmitting the signal, six microphones for receiving the echo, and a depth-finder for measuring accurately the interval between signal and echo. The method is accurate to within about ±5 fathoms or 30 feet for depths greater than 100 fathoms, the range over which the sonic depth-finder is designed to operate.

In marine biology it is planned to confine attention to microbiology, to determine the abundance and distribution of plankton and other microscopic organisms. Shallow-water dredging for diatoms and foraminifera will be undertaken also in cooperation with Dr. Albert Mann, a research associate of the Carnegie Institution of Washington. Quantitative distribution of plankton at various depths from the surface down to 100 meters will be determined by the examination of definite quantities of water brought up by means of special water-bottles, or by use of a hose let down to depths found practicable.

Some study will be made also of surface plankton by straining a continuous stream of water through a fine-meshed net. Marine organisms also will be secured by tow-nets, and hauls both vertical and horizontal are to be made from the surface down to a depth of 150 to 200 meters. A special boom-walk has been rigged in connection with the vessel's boat-boom, where the observer can walk out thirty feet from the ship's side in fair weather, dip up any marine life from the surface, or operate the tow-nets well out from the disturbing influence of the vessel and its motion through the water.

To assist the biologist in his study of marine life in its native habitat at the bottom of the ocean, a diving helmet has been secured for use in shallow-water. This device has been used by amateurs at depths of thirty feet and can be used safely at depths of fifty to one hundred feet.

Equipment will be carried also for securing specimens of dolphins and porpoises from regions where no specimens have been secured heretofore. Such specimens are of special interest to Remington Kellogg, a research associate of the Carnegie Institution of Washington, in his study of the evolution of the whale and other marine vertebrates.

Limited space on the vessel and time and restrictions as to power and machin-

ery prohibit undertaking any deep-sea trawling or dredging. This work may be taken up during a later cruise, when it is hoped that chief attention may be devoted to work in oceanography.

Any program of oceanographic investigations should include extensive work in marine meteorology in view of the important influence upon climate of mass movements of large bodies of heat-bearing oceanic waters. The study of the physical interchange between the surface of the ocean and the air above it is important in the study of atmospheric circulation and disturbance over the entire surface of the earth because of the fairly normal conditions which exist at sea.

The foundations of the science of marine meteorology were laid by an American, Admiral Matthew Fontaine Maury. His book "Physical Geography of the Sea" is still a classic, although some of his theories and conclusions have been supplanted. Due to his efforts an international conference was held at Brussels in 1853, and a general program for marine meteorological observations was adopted. Maury introduced sailing directions and pilot charts which were of untold value to shipping interests, especially in the time of sailing ships. Monthly pilot charts of the great oceans are now issued in advance by the Hydrographic Office and the British Admiralty and constitute a most important aid to navigation.

While conditions at sea are fairly normal for the study of the atmosphere, yet the ocean is only a highway and the observer is always on the move from place to place. Instruments must be especially adapted for use on moving and rolling platforms, and progress in marine meteorology, as in other oceanographic investigations, has developed only as rapidly as the invention and utilization of the proper instrumental equipment has permitted.

To study the physical interchange of heat and moisture between the ocean and the atmosphere, it is planned to observe the temperature and humidity lapse-rates from sea-level to masthead. Accompanying observations of wind direction and velocity and of changes in atmospheric pressure will be made.

Variations in the amount of solar radiation received at the earth's surface and their influence upon world-wide weather conditions have been the subject of much study in recent years by Abbot and Clayton. It has been thought worth while to include such observations in our meteorological program, together with observations of cloud systems, rainfall, evaporation, and dust-content and carbonic-acid content of the atmosphere. Increased data of these kinds over the great oceanic areas to be covered by the next cruise of the *Carnegie* may be extremely valuable in the comparison of world weather with solar variation, in the determination of the rate at which the atmosphere is being charged with water vapor so vital to life on the continents, and in the study of the dynamics of atmospheric circulation over the oceans.

It is planned to compute at sea and publish promptly as the cruise progresses the pertinent oceanographic data for use of students and investigators of oceanography, as has been done heretofore in terrestrial magnetism. The physical data to be published include the following results of observations and calculations at various depths: Temperature, salinity, density observed and corrected for compression, oxygen-content, hydrogen-ion concentration, specific volume, and dynamic pressure and depth. A part of the water-samples will be tested for salinity and for gas-content, and a part will be stored below decks for later study in various laboratories. Biological specimens will be studied, sketched and preserved for transmission to some museum.

The dynamic calculations will be made in accordance with the method devised by Bjerknes and as modified by Hesselberg, Sverdrup and others. The dynamic conditions in the ocean may be viewed in the same light as similar conditions in the air. Winds blow obliquely from areas of high pressure towards areas of low pressure, taking into account the effect of the rotation of the earth. The force or velocity is proportional to the gradient or difference in pressure. So in the ocean, data as to temperature and density at two points at the same level permit us to calculate the difference in dynamic pressure between the two points. This is one of the factors which cause circulation, and the direction of this circulation also is affected by the rotation of the earth.

In the biological and chemical work, chief emphasis will be placed upon the collection of data and specimens. Some analysis of water-samples and study of specimens must be done on board ship immediately after collection, and as complete a preliminary examination and report as possible of the results of these investigations will be made as the cruise progresses. Interested organizations will be furnished with water-samples, bottom-samples and biological specimens for further study and report, and a final discussion and publication of the results of the cruise will be made by the institution at the conclusion of the work.

The Carnegie Institution of Washington is indebted to the following institutions and organizations for cooperation by lending special equipment or by giving expert advice in planning the program of investigations: The United States Navy Department, the National Museum, the Weather Bureau and the Coast and Geodetic Survey; the Scripps Institution of Oceanography of the University of California; the Museum of Comparative Zoology of Harvard University; the School of Geography of Clark University; the Geophysical Institute, Bergen, Norway; the Marine Biological Association of the United Kingdom, Plymouth, England; the German Atlantic Expedition of the *Meteor;* and the Carlsberg Laboratorium, Copenhagen, Denmark.

In this outline of the purpose and progress of ocean-surveys it is possible to present only a few of the outstanding developments and to sketch only briefly the problems as yet unsolved. The chief advances in surveys already made have come from invention of instruments capable of revealing the variations in natural phenomena in regions hitherto inaccessible. Thus the pathway to further progress in these branches of geophysics is made plain, and man's inventive genius is challenged in no uncertain terms.


R.O. del.
First Sketch of
Archeopteryx
restored
by
Richd. Owen
for his friend. Prof. Hitchcock

THE EARLIEST RESTORATION OF ARCHAEOPTERYX

By Dr. HERBERT FRIEDMANN
AMHERST COLLEGE

In this age of popularization of science by methods of visual education most of the more remarkable and noteworthy fossil animals have had the peace of their age-long slumbers rudely disturbed by the modern scientific artists, who, working under the direction of the paleontologists, with something of the aim, but not the methods, of the equally modern beauty-specialists, have attempted to restore flesh to sunken cheeks, to instil the luster of eager eyes in hollow sockets, to impart the appearance of life and vitality in frames so old and decrepit as to be utterly unable to bear the weight of their new rotund habiliments of flesh and muscle.

Archaeopteryx has been the subject of a greater number and variety of restorations than have most fossil types, and the dissimilarities in the various restorations are probably due to differences in the knowledge, acumen and imagination of their respective designers. However, it is quite certain that each prospective restorer is influenced to some extent by the attempts of his predecessors, and works either to emphasize their errors by contrast with his own accuracy, or to modify their lines and proportions in accordance with new-found facts and more recent theories. Consequently it is interesting to examine the very first attempt at a restoration of this famous bird, inasmuch as it is probably the only one that is wholly original, based on only one man's observations, and uninfluenced by the concepts and imaginations of previous workers.

The museum of the biological laboratory at Amherst College is fortunate in possessing the original sketch of Archaeopteryx drawn in Sir Richard Owen's own hand and labeled by him "First Sketch of Archaeopteryx Restored." It was given by Owen to Professor Hitchcock, then professor of natural history in Amherst College, and has since been deposited in the college museum where it now is. This drawing has never been published and is, as may easily be seen from the photography, only a rough, unfinished sketch.[1] The drawing is in ink on a piece of very thin paper which is pasted on the heavier paper on which the writing appears. The ink and the paper are both somewhat brown with age, but the lines are very clear and distinct. The boldness of the outlines indicate that the mental image Owen had of the creature was definite and sure. Of all parts indicated by him in this sketch the bill has been changed the most by more recent restorers, while the free digital claws in the wing have also been made more prominent by his successors. It is curious to note his spelling of the generic name of the animal, and to find that in his earliest attempt at restoring it he used the name presently held and not the name *Griphornis* which he had coined for it. Whatever its merits and demerits may be as judged by the more recent restorations based on fuller and more accurate knowledge of the structure of the animal, it is certain that merely as a restoration (in the sense of bringing a dead animal to life again) it is more successful than many of its more ambitious successors.

[1] In the reproduction the length has been reduced from 8½ to 7½ inches.

never satisfies me, & the conclusion which I continually draw is that "here is a grand suggestion for many years work."—

Your last work must have cost you very much labour & therefore I infer that you are strong & well.— I can assure you that I have by no means forgotten my short & very pleasant interview with you.

Believe me, my dear Sir

Yours sincerely

Ch. Darwin

DARWIN ON SPENCER

By BERNHARD J. STERN
NEW YORK, N. Y.

The recognition of the significance of Darwin's "Origin of Species" was due primarily to the militant, propagandistic zeal of Thomas Huxley and Herbert Spencer, who for a period were almost alone in their advocacy of the theory of evolution. One would suspect, therefore, that Darwin, cognizant of the service Spencer had rendered, was appreciative and was kindly disposed toward Spencer's writings. Yet his reactions toward Spencer's work, as revealed in his letters, are variable, oscillating from extreme unbounded praise to sharp critical appraisement. One discerns in his disparaging letters the incompatibility of the approach of the two men: Darwin, the inductive scientist, cautious of generalizations, the patient gatherer of data; Spencer, the dialectician, the master of striking deductive generalizations.

As early as 1866, Darwin, after reading Spencer's "Principles of Biology," wrote of J. D. Hooker: "I feel rather mean when I read him; I could bear and rather enjoy feeling that he was twice as ingenious and clever as myself, but when I feel that he is about a dozen times my superior, even in the master art of wriggling, I feel aggrieved. If he had trained himself to observe more, even if at the expense, by the law of balancement, of some loss of thinking power, he would have been a wonderful man."

In his letter to E. Ray Lankester in 1870, he commends him on his appreciation of Spencer and concludes: "I suspect that hereafter he will be looked at as by far the greatest living philosopher in England; perhaps equal to any that ever lived." In the same effusive strain he wrote in his letter to Herbert Spencer, in 1872, after congratulating him on a polemical article on evolution which had appeared in the *Contemporary Review:* "Every one with eyes to see and ears to hear (the number, I fear, are not many) ought to bow their knee to you, and I for one do."

A decidedly opposite reaction is that revealed in his letter to John Fiske, in 1874: " . . . With the exception of special points I did not even understand H. Spencer's general doctrine; for his style is too hard for me."

That this letter to Fiske does not merely display a passing mood is shown by a hitherto unpublished letter of Darwin to Lewis H. Morgan, the American anthropologist, author of "Ancient Society." The letter, found in one of Morgan's scrap-books loaned to the writer by the library of the University of Rochester, is dated Down, Beckenham, Kent, July 9, 1877. It is here given *in toto:*

I thank you kindly for your very kind, long and interesting letter. I write in fact merely to thank you, for I have nothing else to say. I have lately been working so hard on plants, that I have not had time yet to glance at H. Spencer's recent work, and hardly to do more than glance at your last work. But I hope before very long to find more time. It is, however, a great misfortune for me that reading now tires me more than writing,—that is, if the subject sets me thinking. I am as great an admirer as any man can be of H. Spencer's genius; but his deductive style of putting almost everything never satisfies me, and the conclusion which I eventually draw is that "here is a grand suggestion for many years' work."

Your last work must have cost you very much labour and therefore I infer that you are strong and well. I can assure you that I have by no means forgotten my short and very pleasant interview with you.

Believe me, my dear Sir—

Yours sincerely,

(Signed) CH. DARWIN

MAIN BUILDING OF VANDERBILT UNIVERSITY

THE PROGRESS OF SCIENCE

THE AMERICAN ASSOCIATION AT NASHVILLE

THE meeting of the American Association for the Advancement of Science and the affiliated national scientific societies at Nashville was successful beyond expectation. There were more than 1,200 addresses and papers on the program, which compares favorably with the meetings in the large cities of the eastern and central states. If each paper is of the average length of ten pages, when prepared for the press, then the proceedings, if printed in full, would fill twenty-four volumes. The issues of *Science* for January 27 and February 3 will be devoted to accounts of the meeting by the permanent secretary and the secretaries of the various organizations. These issues can be obtained free of charge from the office of the permanent secretary in the Smithsonian Institution, Washington, by members of the association who do not receive *Science*.

The opening general session was held on Monday evening in the auditorium of the beautiful Nashville War Memorial Building. The first address of welcome was made by Dr. James H. Kirkland, chancellor of Vanderbilt University, representing also The George Peabody College for Teachers, Ward Belmont School for Women and the Tennessee Academy of Science. The second address was by Judge Grafton Green, chief justice of the Supreme Bench of Tennessee, who began an address which maintained high standards of intellect and eloquence by relieving all embarrassment of visiting members through the explanation that as chief justice of the state he could assure them that no Tennessee law would interfere with any of their discussions, even if they were carried on in public schools not then in session. Any member of the association who might suppose that

CHEMICAL LABORATORIES OF VANDERBILT UNIVERSITY

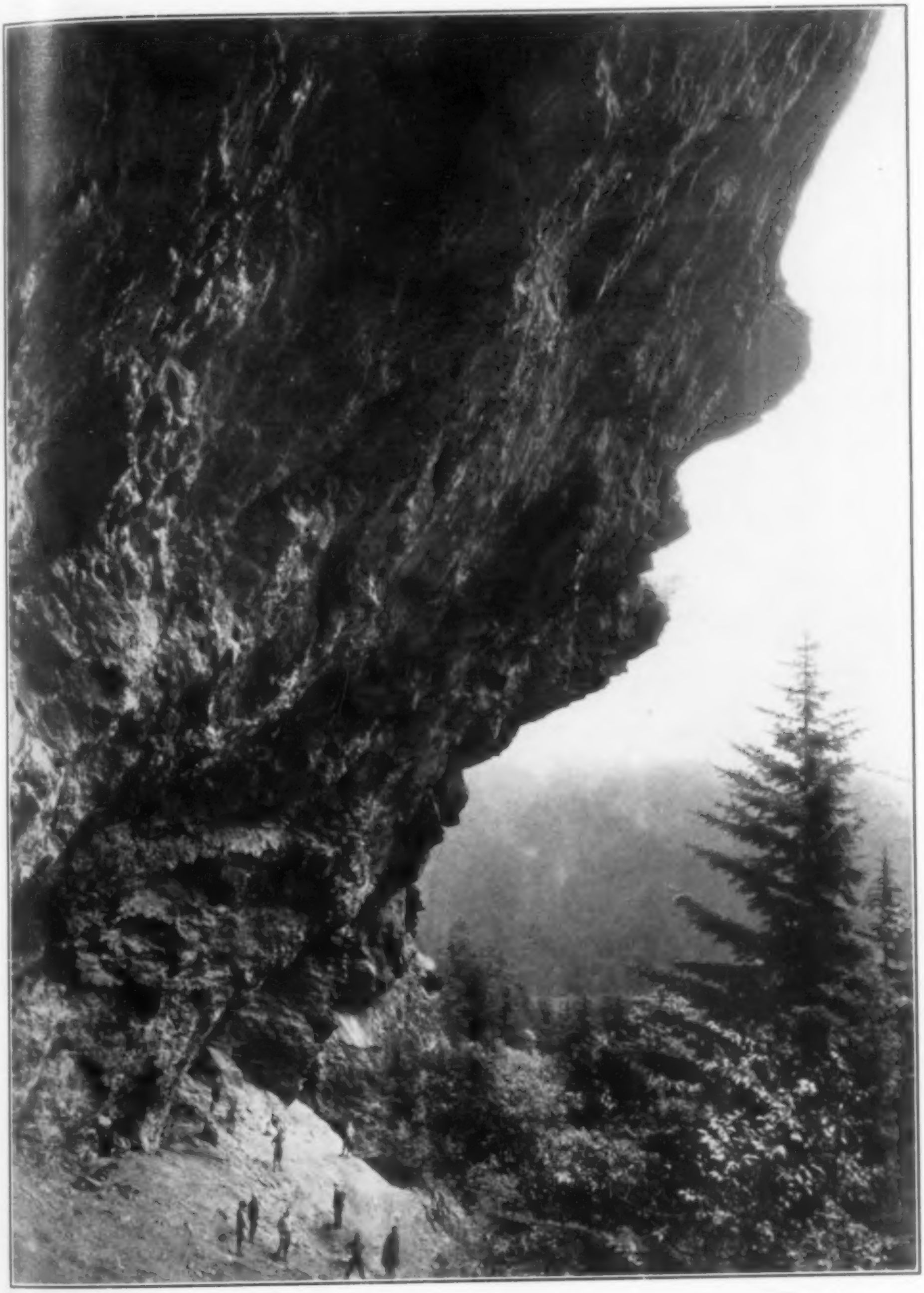
ADMINISTRATIVE BUILDING OF GEORGE PEABODY COLLEGE

missionary work on behalf of evolution was needed at Nashville must have had small knowledge of the high standing of the educational institutions of the city.

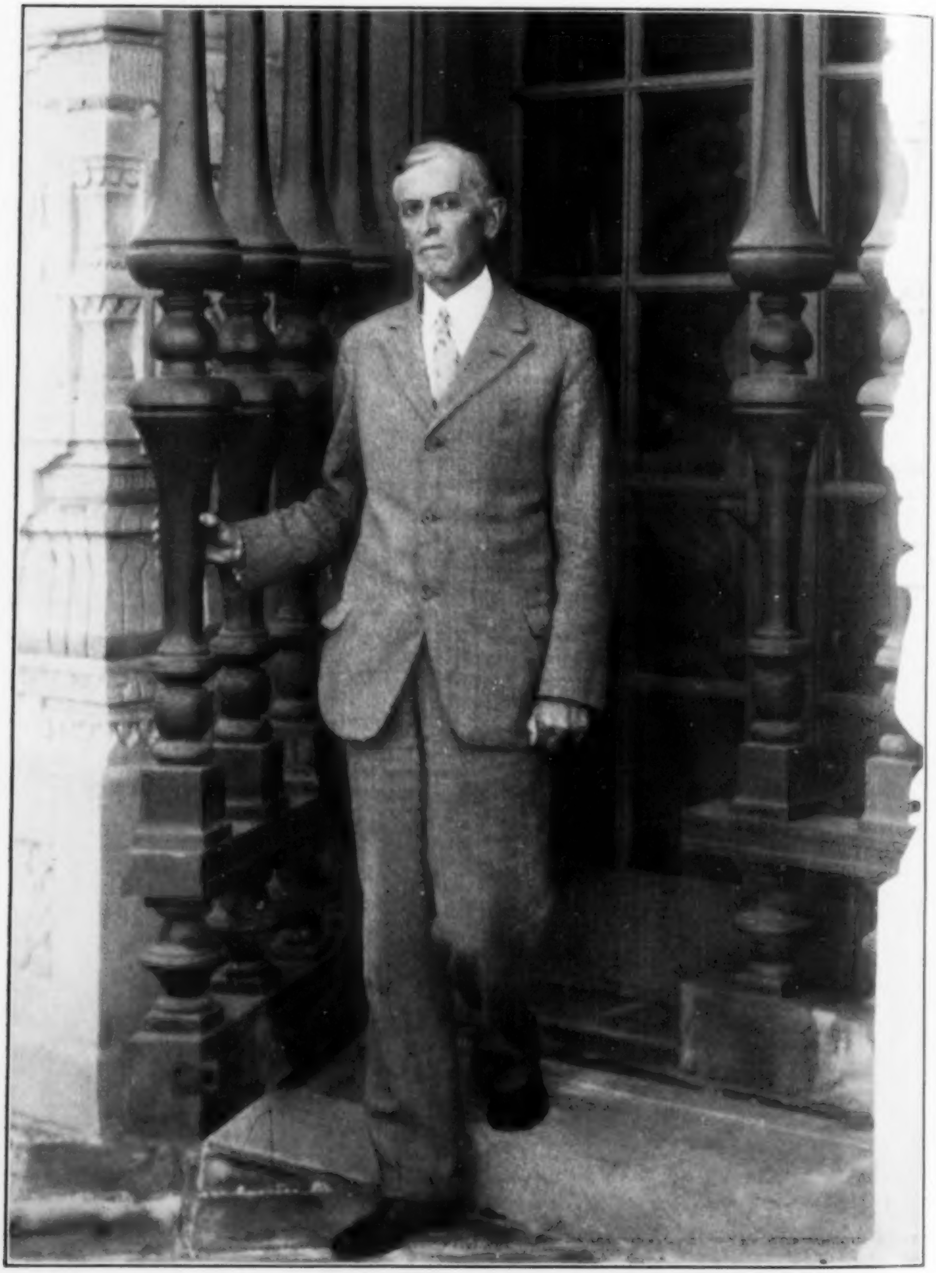
Dr. Arthur A. Noyes, of the California Institute of Technology, who then took the chair as president of the association, made an admirable address. The address of the retiring president, Dr. Liberty Hyde Bailey, which should have followed, was not given, owing to the serious illness from which Dr. Bailey is recovering, but too slowly to make it possible for him to be present at Nashville. In place of this address, Dr. Sylvanus G. Morley gave an illustrated lecture on the explorations of the Carnegie Institution in Yucatan, showing in a most interesting way the remarkable culture developed 2,000 years ago by the Maya in southern Mexico and northern Central America.

Brief references only can be made to other general sessions, which included the sixth annual Sigma Xi lecture, by Dr. Clarence C. Little, of the University of Michigan, who spoke on research in mammalian genetics, to which subject he has made notable contributions continued even with the multifarious engagements of a university president. The fifth Josiah Willard Gibbs lecture, under the auspices of the American Mathematical Society, was given by Dr. Ernest W. Brown, professor at Yale University, as was Gibbs. Dr. Robert C. Aitken, director of the Lick Observatory, gave an address on Edward Emerson Barnard, one of the greatest American astronomers, who was born in Nashville in 1857.

Dr. W. E. Ritter, emeritus professor of zoology in the University of California and director of the Scripps Institution of Oceanography, recently serving as president of Science Service, lectured on science and the newspapers. The distribution of scientific knowledge was also the subject of an all-day discussion arranged by Austin H. Clark, of the Smithsonian Institution, who has for several years been in charge of the press service of the association. Another symposium of general interest, arranged by Dr. Rodney H. True, secretary of the Association's Committee of One Hundred on Scientific Research.



ALUM CAVE BLUFF
ON THE SOUTH SIDE OF MOUNT LE CONTE IN THE GREAT SMOKY MOUNTAINS



PROFESSOR A. A. NOYES

RETIRING PRESIDENT OF THE AMERICAN ASSOCIATION. THE PHOTOGRAPH WAS TAKEN AT THE ENTRANCE OF THE GATES CHEMICAL LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, OF WHICH PROFESSOR NOYES IS DIRECTOR.

DR. HENRY FAIRFIELD OSBORN

President of the American Association. Dr. Osborn is president of the American Museum of Natural History and research professor of zoology in Columbia University.

was on the economic relations of science workers.

Among excursions were a visit to the "Hermitage," the home of Andrew Jackson, in the vicinity of the city and a long excursion following the meeting to the Great Smoky Mountains as guests of the Chamber of Commerce. A national park is planned there, where the flora and fauna are exceptionally rich and many peaks rise to more than 6,000 feet above sea-level.

AN INTERNATIONAL CONGRESS OF PSYCHOLOGY IN AMERICA

THE international scientific congresses that have developed in the course of the past fifty years have contributed much to the advancement of science by promoting the exchange of information and increasing friendly intercourse among scientific men. This is accomplished not only at the meetings, but remains afterwards as a permanent endowment yielding high dividends paid in mutual understanding and good-will.

The resumption of international congresses after the war was needlessly delayed by the action of the National Research Councils established largely as war measures and carrying over to the relations of scientific men emotional attitudes that it is their business to minimize. Scientific men of nations with whom we had been at peace for years were even excluded from the International Congress of Mathematicians held at Toronto in 1926. The congresses for psychology and physiology, held, respectively, in Oxford and in Edinburgh in 1923, were the first in which all nations were invited to take part on equal terms. Now these two congresses have arranged to meet in America in 1929.

International congresses for botany, soil sciences and philosophy were held here last year, and there will now be international congresses in all the sciences with a tendency to meet in the United States. Before the war there had been held here successful congresses in chemistry and in zoology, but in general there had been difficulties in the way of obtaining the attendance of European men of science, the psychological distance westward being much longer than eastward. Plans were made for a psychological congress in the United States in 1912, but it appeared to be doubtful whether there would be a considerable attendance from abroad unless we were prepared to pay the traveling expenses of foreign members, their general attitude at that time being that we could supply the money and they would supply the science.

At the Oxford Congress a preference was expressed for a congress in America in 1926, but it was finally held in Holland. The congress of next year follows an invitation of the American Psychological Association decided on at the Philadelphia meeting a year ago. A committee on organization was then named and the officers and other members of the national committee were elected by a nominating and a formal ballot of members and associates of the association. At the recent Columbus meeting the plans for the congress were adopted and a meeting was held of the national committee, eighteen of the twenty-one members being present.

It is expected that the congress of 1929 will be the largest gathering of psychologists in the history of their science, which does not long antedate the first congress held in Paris in 1889, the first chair of psychology in any university having been established at the University of Pennsylvania in 1888. The American Psychological Association was organized in 1892, with twenty-six members, some of whom would not now be classed as psychologists. There are at present some six hundred members and two hundred associates, all of whom are or have been engaged in professional psychological work.

America surpasses every other country, perhaps all countries combined, in the number of its psychologists, and it is here that educational psychology has received its chief development. We are relatively backward in several other departments, such as medical and industrial psychology, so the congress should be of special value to all who take part in it. Provision will so far as possible be made to assist in defraying the cost of travel for foreign members by lectureship and similar engagements.

The congress will be held at Yale University, New Haven, Connecticut, probably in the week of September 1, 1929. The officers are: *President*, J. McKeen Cattell, New York; *Vice-president*, James R. Angell, Yale University; *Secretary*, Edwin G. Boring, Harvard University; *Treasurer*, R. S. Woodworth, Columbia University; *Foreign Secretary*, Herbert S. Langfeld, Princeton University; *Executive Secretary*, Walter S. Hunter, Clark University; *Chairman of the Program Committee*, Raymond Dodge, Yale University.

In addition the national committee includes J. E. Anderson, University of Minnesota; Madison Bentley, University of Illinois; E. A. Bott, University of Toronto; H. A. Carr, University of Chicago; Knight Dunlap, Johns Hopkins University; S. W. Fernberger, University of Pennsylvania; William McDougall, Duke University; W. B. Pillsbury, University of Michigan; C. E. Seashore, University of Iowa; L. M. Terman, Stanford University; E. L. Thorndike, Teachers College, Columbia University; H. C. Warren, Princeton University; M. F. Washburn, Vassar College, and R. M. Yerkes, Yale University.

ADVANCES IN BIOPHYSICS

The annual American Association prize of one thousand dollars is awarded each year to the author of a notable contribution to the advancement of science presented at the meeting of the association and the organizations that meet with it. This is not a competitive prize, as would be understood from newspaper reports, but a recognition of some paper of outstanding importance and interest. This year the award went to Professor H. J. Muller, of the University of Texas, one of several distinguished students and workers with Professor T. H. Morgan in the new field opened up by him in the study of mutations in the fruit-fly, *Drosophila*.

Professor Muller's recent work is perhaps not more important than his previous researches, but it is certainly of striking interest and his paper at the International Congress of Genetics in Berlin last summer, where comparisons were possible, was regarded as the leading contribution. An account of his work was given in the issue of this magazine for July last.

Briefly, Professor Muller finds that by treating the flies with X-rays, the genes, or hypothetical hereditary particles, are affected, so that mutations occur much more frequently, 150 times as often as in nature. If mutations can be produced artificially and at will in plants and animals, the work of the animal and plant breeder will be greatly accelerated. We shall no longer need an empirical genius, such as Burbank, but shall obtain our results by quantitative laboratory methods.

X-rays have long been the tool of the physicist in studying the intimate structure of matter, but only recently has the biologist begun to realize the fact that this form of energy can also throw light upon many of his problems. Medicine has, of course, utilized X-rays for many years as a method of observing and photographing the inner portions of the human body; and this form of radiation

is used extensively—and with fair success—in the treatment of cancer. Ultra-violet light has recently become important in the prevention and treatment of rickets and generally as a substitute for the sunlight cut off by modern methods of living.

Professor Muller's paper was by no means the only one at Nashville concerned with the effects of radiations on organisms. Professor Winterton C. Curtis and Raymond A. Ritter, of the department of zoology at the University of Missouri, told of their researches on the effects of X-rays on the development of growing tissue. Professor Frank B. Hanson, of Washington University, St. Louis, who has been collaborating with Professor Muller, reported the effects of the rays on the rapidity with which flies reproduce. Professor Robert T. Hance, of the University of Pittsburgh, told of some of the first results of X-ray experiments on warm-blooded animals. The hair color of mice exposed to very light doses of the rays in his laboratory was radically changed. Dr. H. J. Bagg, of the Memorial Hospital, New York City, and Dr. Clarence R. Halfer, working in collaboration, were among the first to obtain positive results with warm-blooded animals. Their mice developed certain marked bodily defects, such as possessing only one kidney instead of two, abnormal eyes, and legs in bad condition at birth. Such defects, like the mutations caused by Dr. Muller, occur among mice bred under ordinary conditions, but not so often as among X-rayed animals.

Plants as well as animals respond to X-ray treatment. Professor T. H. Goodspeed, of the University of California, has obtained results in the breeding of X-rayed tobacco plants which are comparable with those of Professor Muller on fruit-flies. The new varieties produced in this way have a stronger growth and produce more flowers than their cousins descended from un-rayed parents. Professor L. J. Stadler, of the University of Missouri, has conducted similar experiments with corn and barley.

Ultra-violet radiation, now widely used for the promotion of human health, has been shown to be able to promote plant growth as well, and to increase the production of valuable plant ingredients. Experiments in this field were reported before the Botanical Society of America by Miss Adelia McCrea, of Parke, Davis and Company, Detroit. Ultra-violet light has the power to kill as well as cure. Experiments were reported by Professor A. Brooker Klugh, of Queen's University, Kingston, Canada, showing that the short length ultra-violet radiations of the sun are deadly to the minute crustacea that furnish food for the fish of commerce.

PROFESSOR J. VON WAGNER-JAUREGG: NOBEL PRIZE WINNER, 1927

The disease general paresis or dementia paralytica has been well recognized now for over a century. The description of it in Ibsen's *Ghosts* is but little overdrawn. Besides being one of the commonest forms of insanity, it has always been regarded as one of the most hopeless. The treatment by synthetic arsenic compounds which is so effective with other forms of syphilis usually serves only to make it worse.

In 1887, von Wagner-Jauregg, at that time a young assistant in the great psychiatric clinic in Vienna, undertook to look up the cases in which spontaneous recovery had occurred in this supposedly incurable disease. He found that some intercurrent febrile infection had ushered in the improvement in a large majority of such cases. It was but a step to think of inducing an artificial fever; but febrile states are not

PROFESSOR J. VON WAGNER-JAUREGG

easy to produce and control at will. He tried the effect of administration of small amounts of tuberculin, which brought about temporary improvement in some instances. This proved enough of a success to prompt him to use typhoid vaccine intravenously in a series of cases some years later. However, the benefit was never sufficiently striking or permanent to cause psychiatrists elsewhere to take up the treatment, and in general little notice was taken of it. The discovery of salvarsan in 1905 completely eclipsed further similar therapeutic experiments for several years.

Meanwhile, the young assistant found many other things to occupy his mind. He became privat-docent, and finally professor. His practice grew, and always with it his reputation as a sympathetic, careful, skilled physician. He conducted various clinical and anatomical *Arbeiten*. Of these, one stands out with particular sharpness to-day: the suggestion that iodine should be added to table-salt for the prevention of goiter, as is now being done on a large scale in this country and in Europe. von Wagnér-Jauregg revived the idea—which, however, was not original with him—in 1892, and produced fresh evidences of its advisability. Although his recommendations were not put into practice, they undoubtedly paved the way for the recent work of Marine and others which has proved of such great importance.

The further development of the fever treatment of paresis was in a sense a result of the war. Malaria was unknown in Austria for many years, until brought back by soldiers returning from Italy and the Eastern front. Here for the first time were many fresh cases of a recurrent paroxysmal febrile disease whose course was well known and one for which an effective remedy was at hand. The experiment of transmitting a second serious disease to a patient with paresis was easily justifiable in view of the utterly hopeless prognosis of the latter condition. Perhaps, however, it was also easier for the professor—now also *Hofrat*—than for the assistant of thirty years before. So in 1917, von Wagner-Jauregg inoculated nine paretics from a soldier with untreated tertian malaria, allowed them to have a series of several chills, and then administered quinine. All were improved; and on investigation, four years later, three of them were found to be alive and able to work—an unprecedented success. It was found that the inoculated malaria ran a benign course, and could be safely and surely cured at will by a single dose of quinine.

The report of the first cases was met with general skepticism, which has been only gradually overcome. France and the United States have been perhaps the most conservative, but even here the treatment is being used on a large scale, and the reported results are favorable. Naturally, early cases respond much better than advanced ones. Various modifications of the treatment have been suggested—for example, the intensification of the fever by means of hot baths, and the use of the spirillum of relapsing fever instead of the malarial parasite—but von Wagner-Jauregg's original method is still the standard. The treatment has also been extended to other conditions, but it is still too early to estimate its value in them. Encephalitis and multiple sclerosis appear to be little affected by it, but favorable reports of its use in primary syphilis and locomotor ataxia are available.

Professor von Wagner-Jauregg's seventieth birthday was celebrated in April of this year. It is fitting enough that the whole scientific world should join his patients and his students in their congratulations.

T. J. P.